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**THE
BRITISH ENCYCLOPAEDIA
OF MEDICAL PRACTICE**

INCLUDING

**MEDICINE SURGERY
OBSTETRICS GYNAECOLOGY
AND OTHER SPECIAL SUBJECTS**

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VOLUME THREE

CATARACT TO DIAPHRAGM DISEASES

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CATARACT

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Reference may also be made to the following titles:

BLINDNESS

EYE EXAMINATION

216.] The term cataract embraces all those conditions in which the lens of the eye becomes partially or completely opaque. *Definition*

Many types of cataract occur. The basic classification divides the opacification of the lens into (1) developmental, and (2) acquired, according to whether the opacity is due to maldevelopment of the structure of the lens, or to pathological processes or senescence. The lens develops during a great part of life, a process in which the event of birth has little or no effect; as far as the first category is concerned, therefore, it is incidental whether the opacity is congenital or not. The second category may be subdivided as follows: (1) primary, due to senescence; (2) complicated, due to some pathological process in the eye; (3) symptomatic, due to some systemic pathological condition; and (4) traumatic. *Varieties of cataract*

Cataracts may also be classified morphologically. On this subject the literature is confused with the multiplication of types which differ but little in their essential pathology, and only in their shape and position. It is, however, of value to define capsular, capsulo-lenticular, cortical, and nuclear types of cataract.

1.—DEVELOPMENTAL CATARACT

(1)—Capsular Cataract

Congenital capsular cataract is a rare condition, characterized by a number of small white opacities lying on the capsule of the lens associated, if situated on the anterior capsule, with remnants of the pupillary membrane, or, if on the posterior capsule, with the remnants of the hyaloid artery or complicating posterior lenticonus. Their aetiology has given rise to some controversy, some workers considering that they are the result of an inflammatory condition, while others regard them as developmental anomalies. The meagre histological findings are variable and can be interpreted in either sense. The condition when uncomplicated rarely interferes with vision, and rarely requires treatment.

(2)—Capsulo-Lenticular Cataract

*Anterior
polar
cataract*

Capsulo-lenticular cataract is polar in position, situated either anteriorly or posteriorly. Anterior polar cataract may occur as a congenital defect, but more often is formed postnatally as a sequel of ulceration of the cornea in infancy, such as occurs in ophthalmia neonatorum. A white plaque occupies the centre of the pupillary area, sometimes small and circumscribed, sometimes occupying the greater part of the pupil, and occasionally sending opaque lines radiating outwards into the lens cortex. Frequently the opacity is prolonged into the lens substance and involves the cortex, but it never reaches the depth of the foetal nucleus. An optical section frequently demonstrates that the extension into the lens substance may be made up of the fusion of several bands, and occasionally normal tissue has been laid down between the capsular opacity and the deeper lesion.

Pathologically the essential changes which occur are an active proliferation of the subcapsular epithelium, and degenerative changes affecting the lens fibres immediately thereunder. Eventually the tissue which has been involved becomes condensed into an almost structureless laminated mass which, despite its resemblance to connective tissue, has been derived from epithelium and has the staining properties characteristic of hyaline material; eventually it may become impregnated with calcium salts. Frequently it is associated with a corneal opacity and other signs of inflammation, demonstrating that it has occurred after the perforation of a corneal ulcer, when the lens had been temporarily in contact with the cornea.

Posterior polar cataract is much more rare, and is usually associated with a persistent hyaloid artery. Sometimes, however, fibrous-tissue formation is very evident, associated with the vascular remnants, and this may invade the lens substance so extensively as to produce a total cataract. In cases of lenticonus, in which a deficiency in the posterior capsule occurs, a posterior polar opacity is the rule. *Posterior polar cataract*

(3)—Lenticular Cataract

Congenital lenticular cataract (zonular or lamellar cataract) is due to the action of a noxa or inhibiting influence during the period of development of the lens. The result is a localized zonular opacity affecting the band of fibres laid down during this period, and, according to the time at which the injurious agent acts, the localized disturbances may be either nuclear or situated in the cortex (see Plate I, c).

With regard to the aetiology: many of these cataracts occur sporadically, and may therefore be due to some metabolic or nutritional disturbance which has affected the individual at an early stage; others are familial and probably depend on some maternal abnormality; others are markedly hereditary, being transmitted by both father and mother; therefore, in these cases, a germinal cause must be assumed. Of the germinal influences we know nothing, and even of the more individual factors our information is somewhat vague, but there is a large body of clinical evidence which associates their development with general malnutritional changes. As they are frequently associated with imperfect calcification of the enamel organs of the permanent teeth, and sometimes with rickets or infantile tetany, their association with calcium metabolism is close, and the fact that experimental extirpation of the parathyroid glands may be followed by this type of cataract brings the condition into relation with changes in the endocrine system. Further, toxic influences may be of importance, for the fact that experimental cataract may be produced in young animals by feeding the mother on naphthalene, makes it conceivable that toxic or infective processes in the mother, as well as malnutrition and errors of feeding, may cause a derangement in the lens of the foetus. *Aetiology*

Histologically, the appearance of such a cataract is relatively constant. Instead of lens fibres, hyaline globules and other detritus representing the remains of lens cells which have failed to develop into fibres, or of fibres which have degenerated, make up the pathological picture. *Histology*

(4)—Less Common Types of Developmental Cataract

Several less common types of developmental cataract are met with: central or nuclear cataract in which a granular or completely opaque area is formed in the nucleus; anterior axial embryonic cataract in which a number of small white dots are situated in the neighbourhood of the anterior Y-suture; floriform cataract in which annular elements, usually grouped together like the petals of a flower, occur in the axial portions

of the lens; coralliform cataract in which elongated processes radiate out in an axial development from the centre of the lens; sutural cataract affecting the Y-shaped sutures; and others.

(5)—Treatment

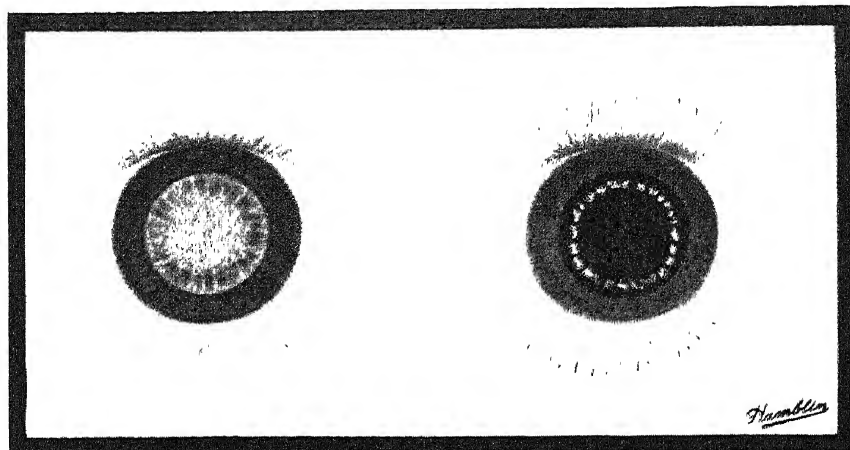
Iridectomy If vision is seriously affected from these changes in the lens, the choice of treatment lies between iridectomy, discission, or extraction. Iridectomy is rarely satisfactory and is advisable only in those cases in which the opacity is limited to the central area. *Discission* Discission is the usual treatment of choice; as a rule the operation should only be attempted when the condition is bilateral and the vision, after correction of the refractive error, is below 6/18, for it is probable that an eye with its lens intact, and which therefore is capable of some accommodative adjustment, and through which a fair degree of vision is possible, is more valuable than an aphakic eye. *Mydriatics* If operation is contra-indicated and the opacities occupy the normal pupillary area leaving a wide peripheral zone clear, vision may be considerably improved by the daily use of a weak mydriatic, a procedure which can be carried on safely for long periods. It should be remembered that the occasional association of a congenital cataract with other ectodermal defects involving the macula, sometimes renders the result of technical operative procedures disappointing.

2.—ACQUIRED CATARACT

(1)—Senile Cataract

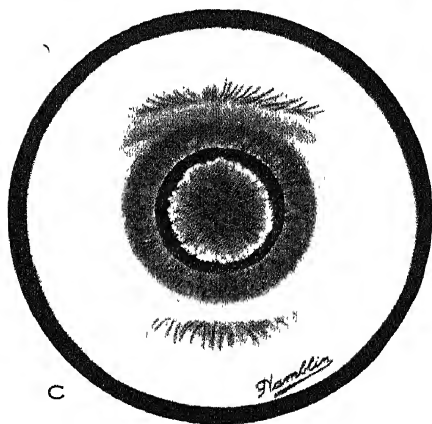
As the normal lens grows older a series of senile changes, which may be considered to be physiological, occur. A progressive increase in optical density and absorbing power gives it a yellow appearance in the beam of the slit-lamp; this is occasionally accentuated by the tint of oxidizing tyrosine, indicating hydrolysis of the proteins; if this substance is oxidized to melanin, black pigment is deposited. Shagreen becomes accentuated, and the relief of the surfaces of discontinuity in the interior of the lens, particularly that of the adult nucleus, increases; the sutures form projections, the design of the fibres is marked off and hemispherical projections, presumably fluid vacuoles, appear. In the cortex large, clear clefts filled with fluid open out the sutures, and vacuolization occurs, and the lamellae become separated both here and in the nucleus.

Accompanying these physiological changes of senility, organic opacities formed by the coagulation of the lens proteins may become evident to some extent. These take the form of well-differentiated morphological 'types', a single one of which is rarely met with as an isolated occurrence, several being usually associated. In this way the distinctive characters of each are to some extent effaced and obscured by the progression of the others, as well as by the accompanying senile changes of lamellar separation and vacuole formation.



A

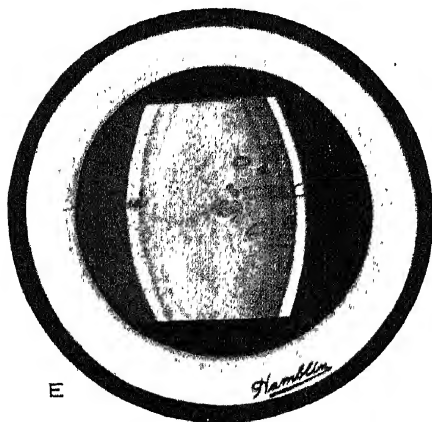
B



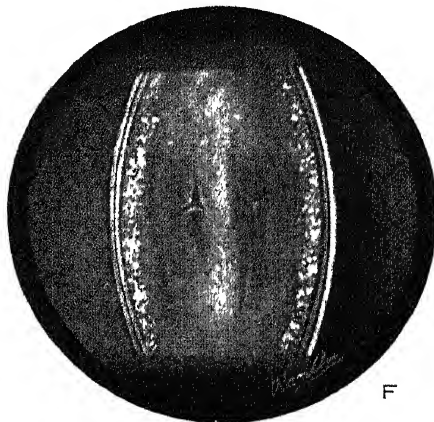
C



D



E



F

A.—Senile cataract ophthalmoscopically. B.—Senile cataract by focal illumination. C.—Congenital lamellar cataract. D.—Complicated cataract with dislocation of lens and detached retina. E.—Early diabetic cataract. F.—Cataract in myotonia atrophica (from *Transactions of the Ophthalmological Society*, 1928)

PLATE I

[To face p. 5

In subjects who are not of advanced years, two 'presenile' types of cataract—coronary and dilacerated—occur which are usually non-progressive and symptomless for long periods until true senile changes become superimposed.

Coronary cataract is an annular zone of club-shaped opacities occupying the outer layers of the nucleus and the inner layers of the cortex. *Coronary cataract*

This is found to some extent in 25 per cent of persons above puberty, and is very slowly progressive. Dilacerated cataract is a thin opaque layer, looking very much like combed-out moss, in the deeper layers of the adult nucleus and the superficial layers of the infantile nucleus. *Dilacerated cataract*

Clinically, senile cataract (see Plate I, A and B) may be divided into two types: cortical and nuclear. Combinations of the two types frequently occur. *Cortical type of senile cataract*

(1) In the former in the incipient stage, radial spokes or sectors of opacity are seen with clear areas lying between them. When the pupil is dilated these linear opacities are seen to broaden out towards the periphery where a more or less generalized opacification is seen. They lie in the cortex of the lens in front of and behind the nucleus, starting from the region of the equator and gradually extending towards the axis of the eye. By oblique illumination they appear grey in colour, and ophthalmoscopically they appear black against the red background of the fundus. They are usually associated with considerable alteration in sectors of the refractive indices of the lens fibres, different areas of the lens appearing light or dark as the refraction of the light is changed, a phenomenon which accounts for the common symptom of unocular polyopia. (2) In the nuclear type of opacity the lens, starting from the centre, becomes diffusely cloudy, gradually clearing towards the peripheral cortex. *Nuclear type*

As the process goes on, the lens fibres attract more water than normal and consequently swell, producing intumescence of the lens. Finally the whole tissue becomes opaque. The cataract is spoken of as clinically mature when the opacity occupies the entire cortex, and so long as any clear lens substance lies underneath the capsule it is said to be immature. *Morbid changes*

The stage of hypermaturity is ushered in by the complete disintegration of the cortex, and its transformation into a pultaceous mass. With further loss of water, the lens becomes shrunken and inspissated. Finally the cortex may become quite fluid and milky so that the nucleus sinks to the bottom of the capsule, producing the condition known as Morgagnian cataract. The rate of development varies greatly, being usually less rapid in old people. Frequently it occupies many years, and, indeed, the condition may never reach maturity. Thus it is not a rare experience to encounter lens opacities which are known to have been present for fifteen or twenty years and yet have not seriously affected the sight. *Morgagnian cataract*

The two initial symptoms of early cataract commonly met with are polyopia due to refractive variations in the lens, and the appearance of spots before the eyes, which, in contradistinction to vitreous opacities, are stationary. Eventually visual acuity diminishes as the central area of the lens becomes affected, until finally, when the cataract becomes *Symptoms*

mature, only perception of light remains. There is no pain associated with the condition.

(2)—Complicated Cataract

Complicated cataract, as has been seen, is the result of a local disease in the eye. Since the lens is nourished by the intra-ocular fluid which is formed essentially by the ciliary body, a complicated cataract is a frequent sequel of cyclitis. Diffusion into the lens is greatest at the posterior pole where the capsule is thinnest, and the cataract therefore appears as thin flaky opacities, situated subcapsularly in the posterior cortex, multiplying towards the centre of the lens and later spreading out into the anterior cortex (see Plate I, D). The areas of opacity are never sharply delineated from the surrounding clear areas, but are submerged in a haze and tend to progress irregularly. A characteristic feature is the polychromatic lustre which, as seen by the slit-lamp, appears as a multicoloured iridescence of the posterior capsule.

(3)—Symptomatic Cataract

There are two types of symptomatic cataract: (a) diabetic cataract, a distinct clinical entity; and (b) a group of cases showing a general morphological and clinical resemblance which are associated with other dyscrasias, particularly those of the ductless glands.

(a) *Diabetic Cataract*

A typical senile cataract will often be found to co-exist with diabetes mellitus, and in such a case it is liable to progress to maturity earlier than in uncomplicated senile cataract. A true diabetic cataract of definite morphological features also occurs, but very rarely. It is characteristic of the disease, and consists of numerous small cloudy opacities immediately beneath the anterior and posterior capsules. Fluid droplets in quantity may appear under the capsule during an exacerbation of diabetes, and in these circumstances a complete opacity of the lens may develop acutely, perhaps within a few days, and may occur in young subjects. See Plate I, E.

(b) *Cataract associated with other Disturbances*

*Morpho-
logical
characters*

Cataracts in this group, all the members of which are similar in that the opacity is cortical, contain iridescent crystals, and come on at an early age. The only other type to which they bear any resemblance is the presenile coronary cataract, which usually develops at about twenty-five years of age, but in this condition the opacities have a peculiar club-shape, occur in the deep cortex and the superficial layers of the adult nucleus, and are seen mainly round the periphery of the lens.

*Mongolian
idiocy*

Mongolian idiocy is complicated by the formation of a multitude of small opacities arranged concentrically round the nucleus, which remains perfectly clear. They are arranged in irregular fashion and are usually disciform, or sometimes annular; they are intermixed with light iri-

descent crystalline opacities. The opacities are confined to the cortex, but as age advances the typical appearance is to some extent lost.

A somewhat similar change is observed in cretinism; small flaky opacities are seen in the superficial cortex with occasional iridescent crystals. The amount of opacity is in direct relation to the age of the subject, but this is only discernible by the slit-lamp, and does not interfere with the acuity of vision. *Cretinism*

Myotonia atrophica (dystrophia myotonica) is characterized by small angular opacities forming a stippled design in the superficial parts of both the anterior and posterior cortex. The space between the anterior capsule and the zone of the disjunction is perfectly clear, as also are the deeper part of the cortex and the nucleus of the lens. Scattered among these whitish opacities are many iridescent crystalline bodies which sparkle with a red and green lustre (see Plate I, r). The cataract usually starts between twenty and thirty years of age and may be considered pathognomonic. For further discussion of myotonia atrophica see MUSCLE DISEASES. *Myotonia atrophica*

Aparathyroidism and tetany are frequently associated with fine flaky or crystalline deposits, often arranged in concentric layers in the cortex, and frequently accompanied by powdery opacities in the nucleus. A somewhat similar cataract may complicate the post-operative myxoedema which develops as a result of the removal of an excessive amount of thyroid tissue. *Aparathyroidism*
Post-operative myxoedema

(4)—Traumatic Cataract

Traumatic cataract is caused by wounds of the lens usually involving a rupture of the anterior capsule. The lens rapidly becomes cloudy in the vicinity of the wound owing to imbibition of water. In addition to the local disturbance, small opacities usually form rapidly in the posterior cortex, first as fine feathery lines, and later as a rosette-like opacity which gradually spreads until the whole cortex is involved. In the meantime the swollen lens fibres may protrude as flocculent masses through the opening of the capsule into the anterior chamber, while the swelling of the lens may culminate in secondary glaucoma. *Wounds of the lens*

Under the heading of irradiation cataract may be included cataract due to an electric current or lightning, and also the radiational cataract which is formed when any kind of radiation is absorbed in quantity by the lens. This occurs readily on exposure to infra-red rays, X-rays, or radium emanations, and less readily with visible or ultra-violet rays. Industrially it is most commonly caused by the infra-red part of the spectrum and is met with in glass-workers (in whom it has long been recognized), ironworkers, and others. Its most characteristic form is a posterior polar cataract, usually taking the form of a meniscus, and it may be associated with changes in the anterior capsule, such as stripping and detachment of the zonular lamella. The type of opacity is quite different from that seen in complicated cataract although it has a similar site, and it also bears little resemblance to senile cataract. Senile *Electric and radiational cataract*

changes, however, usually complicate it at a later stage, and tend to obscure its characteristic appearance. Of late years the widespread use of radium and X-rays in ophthalmology has produced a number of examples of typical radiational cataract, developing specially at the posterior pole. Cataracts due to X-rays first make their appearance about eighteen months or two years after the exposure. It is obvious that, if possible, the eye should be protected by screening whenever X-rays or radium are to be used in its vicinity.

(5)—Treatment

From time to time, and with growing frequency within recent years, the 'cure' of cataract by medical means has been advocated, the suggestions including such alternatives as the application of radium or ultra-violet light (which cause opacity), of massage or electrical treatment (which if anything, will induce a traumatic cataract), or of iodine and other drops. It is true that in some early cases of acute cataract (true diabetic, traumatic), when the process has not progressed to actual coagulation of the proteins of the lens, transparency may be recovered by controlling the exciting conditions; it is also true that in all cataracts variations appear to occur owing to changes in the fluid traffic and alterations in the refraction of the unstable lens; but it is equally true that in all cases an organic opacity, once formed, is immutable. Coagulation of protein is an irreversible chemical change. It seems not unreasonable to hope that, in the future, when our knowledge of this change and of the factors causing it has been more fully developed, it may be possible to prevent its incidence or delay its progression; but in the present state of our knowledge, although it is reasonable to attack and eliminate any exciting cause that is known or suspected, the only effective and legitimate method of treatment is operative removal of the lens.

*Treatment of
refractive
errors*

While cataract is developing, a frequent watch should be kept on the refraction, for this continually varies within wide limits. The most constant change is an increasing myopia due to the relative increase in the refractive index of the nucleus. Tinted glasses are sometimes useful, as they keep the pupils slightly dilated; they usually cause a great increase in definition. If the opacity is central a weak mydriatic may be of value, and is proper provided that any predisposition to glaucoma has been excluded. Restriction in the use of the eyes is unnecessary but care should be taken with the illumination; if the opacities are central a dull light is best, but if they are peripheral a bright light is usually most useful. When the opacities progress so far as to cause serious impairment of vision, operative removal of the cataract should be advised.

Surgery

Operation should only be undertaken if the patient has been carefully overhauled medically, and general disease, such as diabetes mellitus or active focal sepsis, has been excluded. Further, the bacteriological cleanliness of the conjunctival sac should be assured, and any infection of the lacrimal passages eliminated.

Two types of operation are commonly employed: (1) Extra-capsular extraction, in which the anterior capsule is cut and the lens subsequently extracted; at a later stage an opening is made in the posterior capsule by needling. (2) Alternatively an intra-capsular method may be adopted in which the lens is removed with its capsule intact; in this case, of course, no subsequent needling is necessary. The first operation is the older, the commoner, and the safer. The second may be of various types, the most usual being removal of the lens with its capsule by forceps. In either method it is frequently advisable to perform an iridectomy—occasionally a complete iridectomy before the actual extraction of the lens if manipulative difficulties are encountered, more often a small button-hole iridectomy near the root of the iris after removal of the lens as a safeguard against post-operative prolapse of the iris. Whichever method is employed, results are, on the whole, extremely good and in uncomplicated cases it is the rule to obtain vision up to normal standard, with the disadvantage that the plasticity associated with accommodation is lost, and that, except in high myopes, glasses of high power are a constant necessity.

In complicated cases great care should be directed towards controlling the primary disease, and any operative extraction of the cataract should, if possible, be delayed until any intra-ocular inflammation has been quiescent for some time, and recrudescence is unlikely. It goes without saying, also, that in symptomatic cases the general state of health should be as sound as possible, a precaution which is particularly necessary in the case of diabetes mellitus.

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CATARRH

See ACCESSORY SINUSES OF THE NOSE, Vol. I, p. 77;
BRONCHITIS AND BRONCHO-PNEUMONIA, Vol. II, p. 696; *and*
COLDS, Vol. III, p. 271

CATATONIA

See EPILEPSY

CAT-BITE DISEASE

See RAT-BITE FEVER

CAUDA EQUINA DISEASES

See SPINAL CORD DISEASES

CELLULITIS

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Reference may also be made to the following title:

BOILS AND CARBUNCLES

1.—DEFINITION

217.] Cellulitis is an infection of the cellular tissues by pyogenic organisms, in which pus formation is common and there is frequently sloughing of the tissues. Any cellular tissue may be affected, but the term is most commonly applied to the superficial connective tissue, the deeper forms of cellulitis being qualified by their anatomical positions—such as pelvic cellulitis (see p. 15), or by special names—such as cellulitis of the neck (Ludwig's angina). See title NECK: TUMOURS AND OTHER MORBID CONDITIONS.

2.—AETIOLOGY

The disease is caused by the invasion of the subcutaneous tissues by micro-organisms. They enter through an abrasion, either slight or extensive, operation wounds and, perhaps most commonly, through insect bites and pricks. Cellulitis may also be a sequel to boils or carbuncles. The patient may be of any age and of either sex.

3.—MORBID ANATOMY AND BACTERIOLOGY

Causal organisms

The causative organisms are the *Streptococcus pyogenes* and the *Staphylococcus* but other organisms may also be present. In rare cases the organisms responsible for gas gangrene, such as the *Bacillus welchii*, are found, but in such cases the underlying muscles are also infected. The tissues show inflammatory changes, the vessels are engorged and in places thrombosed; the whole of the cellular tissues and fat are greatly swollen with serous fluid and later with pus. The pressure thus produced leads to local necrosis and eventually to sloughing. Spreading from the affected area the lymphatics can be seen as streaks running towards the lymphatic glands draining the area. The glands are enlarged and may break down, with subsequent abscess formation.

4.—CLINICAL PICTURE

Constitutional symptoms

The constitutional symptoms vary with the severity of the infection but not necessarily with the extent of the local lesion; thus a large area of cellulitis may cause little or no constitutional disturbance, whereas with a small lesion this may be so severe as to give grounds for considerable anxiety. The general malaise is most marked in the early stage, and as the disease becomes localized there is usually great improvement in the general condition.

The temperature is raised and there may be rigors, a rapid pulse, and furred tongue. The patient complains of feeling ill, of loss of appetite, and of headache. In some cases there is sleeplessness with delirium.

Local symptoms

The local condition varies with the acuteness of the infection. In the early stages there is only a blush radiating from the primary lesion; later the part swells and the colour darkens, it may be with patchy discoloration amounting to haemorrhagic spots; considerable extravasation of blood occurs in certain types of infection.

Throbbing pain is a feature of cellulitis and is determined by the increased tension of the part. Fluctuation is not usually present even when the local signs of tenderness, redness, swelling, and oedema would point to abscess formation, the pus being diffused throughout the area. The lymphatics draining the region are at first outlined, but they disappear after the first forty-eight hours, and areas of inflammation with subsequent abscess formation may occur along their course.

When the scalp is affected the inflammatory process may be confined to the dense connective-tissue layer immediately under the skin, but more frequently the infection penetrates the occipito-frontalis or its aponeurosis and involves the loose connective tissue beneath that muscle. In such cases the suppuration spreads until the whole scalp is raised, but its further progress is limited by the attachment of the muscle and its aponeurosis.

5.—COURSE AND PROGNOSIS

The infection may be so virulent that the local symptoms are overshadowed by the general, and the patient may die of a septicaemia or pyaemia. More commonly, however, the general symptoms abate, and the cellulitic area is localized, requiring active surgical intervention such as the opening of abscesses. In some cases the whole area of cellulitis resolves with appropriate treatment. When the patients are greatly debilitated, or when their resistance is lowered by other diseases such as diabetes mellitus or nephritis, the local reaction to the infection is poor, and pus formation may be greatly delayed with increase in the local necrosis and sloughing; in such cases death may follow from toxæmia and exhaustion.

When the scalp is the seat of the primary lesion special complications are to be feared owing to the free venous communication; necrosis of the skull may take place, and complications such as subdural abscess and meningitis may prove fatal. *Complications in sea infections*

6.—DIAGNOSIS

The primary blush occurring in the presence of a skin lesion is of considerable significance when associated with malaise and a raised temperature. It may not be possible in the first twenty-four hours to say whether the condition is one of cellulitis or of erysipelas; in the latter case, however, the malaise is usually more severe and the temperature relatively higher. After twenty-four hours the condition is readily diagnosed; there is considerable local swelling with severe, throbbing pain. The presence of enlarged and tender lymphatic glands may be noted. Later, the local condition becomes worse, the oedema and swelling are very well-marked, and in advanced cases fluctuation can be detected.

7.—TREATMENT

As in other acute surgical infections, the treatment of cellulitis should be conservative; early incision should on no account be performed, as this may determine a septicaemia.

The immediate local treatment must be energetic. The affected part should be put at rest and two-hourly fomentations applied; hot baths either of saline or iodine lotion may also be given. If the cellulitis originates in a wound which has been stitched, the stitches should be removed at once; if the infection has arisen from another source local surgical interference should in the early stage be avoided. *Local treatment*

Usually such measures will localize the inflammation, and in this later stage incisions may be made into any area where pus is suspected. *Incisions*

This should be done under a general anaesthetic, and the incision or incisions carried down to the deep fascia, but no further. A large number of incisions should be avoided, the object being to evacuate any pockets of pus that may be present. Incisions made into swollen and oedematous tissues merely determine a sloughing wound in that area, which may be severe and prolong the convalescence. When the pus has been evacuated drainage may be necessary for some days, and at the same time the fomentations and baths should be continued as before. If the area shows signs of becoming sodden, dry heat in the form of an electric cradle may be used instead of the fomentations.

*General
treatment*

General measures should be taken from the outset; a smart purge should be prescribed and the bowels kept open by salines. Nourishing fluid food should be given and in many cases stimulants are required.

Antiserum

As the greater number of these infections are streptococcal, anti-streptococcal serum (antiscarlatinal) should be given, 10 c.c. daily, until the general symptoms have regressed. This is often a life-saving measure and certainly helps to localize the infection.

*Prevention of
contracture*

If considerable sloughing has taken place, measures must be taken to prevent contractures, the part being splinted if necessary, and during convalescence massage with active and passive movements should be employed.

*Incision for
scalp infec-
tions*

In the case of cellulitis of the scalp incisions must be made at an earlier stage than elsewhere; a judicious incision made at the proper time in this situation may prevent spread of infection under the aponeurosis. This incision should be made parallel to the vessels and care should be taken not to incise the pericranium.

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CELLULITIS, PELVIC

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Reference may also be made to the following titles:

ABORTION APPENDICITIS PUERPERIUM

I.—PELVIC CELLULITIS IN THE FEMALE

1.—DEFINITION

218.] The term 'pelvic cellulitis' is used in its broadest sense to indicate a generalized inflammatory condition of the pelvic organs and their supporting tissues; more particularly, it is used in gynaecological practice to describe an acute or subacute inflammation of the parametrium and connective tissues at the base of the broad ligaments. Since this is by far the commonest type of pelvic cellulitis, the gynaecological applications of the term will be considered except where it is otherwise stated.

2.-AETIOLOGY

Gynaecological causes

Pelvic cellulitis in the female is almost always the extension of an uterine infection, and it is usually associated with metritis, salpingitis, and some degree of pelvic peritonitis. In the great majority of infections the causal organism is the streptococcus, which not infrequently is associated with, or is preceded by, a gonococcal infection of the tissues. The commonest determining cause of pelvic cellulitis is an abortion, and usually one which has been induced by unclean methods. Less often it may follow a spontaneous abortion or full-term labour; and it has been known to occur as the sequel to a simple curettage which has been performed without due regard to surgical asepsis. Trauma of the cervix is an especially important factor in its production.

Non-gynaecological causes

Of the non-gynaecological causes of pelvic cellulitis, the most important is an appendicular infection which has extended by direct continuity to the pelvic tissues, or which has secondarily involved the pelvis as a sequel to the escape of pus from an associated appendicular abscess. In a similar manner, diverticulitis, ulceration or perforation of the colon or rectum may result in a pelvic cellulitis. Actinomycosis is a rare but important variety of a slowly progressing pelvic cellulitis which may appear as a sequel to appendicular infection (see Vol. I, p. 176).

Tuberculosis of the pelvic organs may lead to a form of chronic cellulitis with abscess formation (see TUBERCULOSIS).

3.-CLINICAL PICTURE

General symptoms

A case of pelvic cellulitis of moderate severity occurring as a sequel to a uterine infection, is characterized by a sustained pyrexia reaching 102° F. or higher, associated with a considerable amount of pain across the lower abdomen. Vomiting may be present but is not a conspicuous feature; repeated vomiting should raise a doubt regarding the true diagnosis. Rectal and bladder disturbances are not usually seen in the earlier stages, but may appear as the result of pus formation, as will be described later. If the patient has been recently delivered, or has had an abortion, the lochia may be offensive and pus-like in appearance.

Examination of patient

Abdominal examination shows considerable tenderness and often rigidity of the lower abdomen. In the more severe cases some degree of meteorism may be present. By vaginal examination the uterus is found to be bulky and tender, with the cervix still patulous following the abortion, or unusually soft if the case is not associated with a recent gestation. It is characteristic to find that the cervix is fixed in the mid-pelvic position by a firm indurated condition of the pelvic tissues, as felt through the vaginal fornices. This fixation is a conspicuous feature and gives the examining finger the impression that

there is a shelf of bone or cartilage extending from the supravaginal cervix to the pelvic walls. Pressure exerted through the fornices causes considerable pain, as does rectal palpation. Rectal palpation may also reveal some narrowing of the bowel with rigidity of the rectal shelf. At this stage no bulging can be felt; the uterus and cervix lie in their normal positions, but palpation conveys the impression that the organs are embedded in some fixative or exudate.

4.-PROGNOSIS AND COMPLICATIONS

In cases in which the virulence of the infecting organism is high the condition may rapidly prove fatal, with peritonitis and septicaemia as terminal features. Such an outcome is fortunately rare. Far oftener the inflammation, after lasting for many days or weeks, slowly subsides or, in some cases, goes on to abscess formation. The abscess commonly points in one of the fornices. Occasionally, however, the inflammation may extend upwards along the broad ligament and reach the iliac fossa, where it forms a swelling which is easily palpated from the abdomen, and which may in time develop into an abscess. Much more rarely the inflammation may spread along the round ligament and form a swelling over the region of the inguinal ligament. Another rare form of extension is an upward spread along the sheath of the psoas muscle, causing flexion of the leg at the hip-joint, and resulting in a psoas abscess.

*Peritonitis
septicaemia*

*Extension of
inflammatory
process*

As already indicated, in the great majority of cases the inflammatory swelling forms in the immediate neighbourhood of the cervix, and can be palpated from the posterior, or postero-lateral vaginal fornix. With the formation of pus, the swelling increases in size, a softening is felt, and the cervix is pushed forwards against the symphysis pubis. If left to itself, the abscess cavity may reach large dimensions and so distort the pelvic anatomy that an impacted ovarian cyst may be simulated. Rectal palpation is of considerable help in augmenting the information obtained by vaginal examination.

Pus formation

In many of these cases the abscess arises not in the pelvic cellular tissue, but in an associated tubo-ovarian inflammatory mass which has come to occupy the pouch of Douglas. From the point of view of treatment the distinction is not of great importance, for each variety of abscess is best treated by incision and drainage from below.

*Abscess in
pouch of
Douglas*

In untreated cases, an abscess cavity in the pouch of Douglas may reach a large size and contain a pint or more of pus, and not infrequently ruptures into the rectum. Before this happens characteristic signs and symptoms appear. The patient is unable to control the anal sphincter and semi-fluid faeces escape at intervals. Alternating with this there is a discharge of clear or straw-coloured mucus from the anal orifice. On passing a finger into the rectum complete absence of tone of the anal sphincter is noted, and two or three inches above the

anal orifice a tense cystic mass is felt filling the pelvis and pressing against the rectum.

*Diagnosis of
abscess in
pouch of
Douglas*

The condition most likely to be confused with an abscess in the pouch of Douglas is an ectopic gestation with associated pelvic haematocele. In both conditions there is local swelling and tenderness, and in both there may be some pyrexia, although this seldom amounts to more than 100° F. in the case of a pelvic haematocele. The menstrual abnormalities associated with ectopic gestation should help in the differential diagnosis. In this connexion both the preceding amenorrhoea (present in only two-thirds of the cases of ectopic gestation), and the irregular slight bleeding which appears with the onset of abdominal symptoms, should be kept in mind. In cases of doubt it is permissible to puncture the pouch of Douglas with a stout needle and to aspirate the contents of the fluid swelling. This diagnostic procedure, however, should only be carried out in an operating theatre where everything is in readiness for a laparotomy should a pelvic haematocele be diagnosed.

In the differentiation from an ovarian cyst the history may provide valuable help. Pyrexia is absent, and there is seldom any marked degree of local tenderness unless the cyst has undergone recent torsion. Further, it is rare for an ovarian cyst to be pressed down into the pelvis unless it is of considerable size, which makes its presence by abdominal palpation easily determined.

5.—TREATMENT

In the acute stages of pelvic cellulitis the patient should be nursed in the Fowler position. No local treatment should be undertaken save the application of hot fomentos to the lower abdomen, kaolin poultice being comforting to the patient. A daily hot douche at a temperature of 115° F. should also be given; saline solution, 2 teaspoonfuls of common salt to a pint of water is suitable. Mild saline aperients are indicated, and it is important to make sure that the patient sleeps well at night. In the subacute stages, when the local tenderness is lessening, nightly tampons of ichthammol 10 per cent in glycerin may be used, although the value of this treatment is a little doubtful. The hot douches may be increased in number at this stage. If the illness drags on in the subacute form for some weeks, it is often useful to nurse the patient in the open air exactly as for pulmonary tuberculosis. Under this regime the patient sleeps better, the general metabolism is stimulated, and the appetite improves considerably.

Hot douches

Diathermy

In resistant cases pelvic diathermy is of value, but should not be undertaken until the temperature is consistently below 100° F.; a vaginal electrode is introduced high into the vault of the vagina and the second electrode takes the form of a lead belt drawn round the pelvis. The treatment is given daily, starting with five minutes, and gradually

increasing to twenty minutes. It is impossible to lay down exact rules for the duration and intensity of the treatment, since this varies with the type of electrode and the type of diathermy apparatus used. It can be said, however, that with the usual vaginal electrode, measuring $1\frac{1}{2}$ inches in diameter, it is permissible, with most machines, to use a current intensity of two to three amperes. (See article on DIATHERMY.)

Twice weekly a vaginal and rectal examination should be carried out, and if pus formation is detected, the abscess should be opened by *Incision of abscess* incision from below; this may be done either from the rectum or vagina, most gynaecologists preferring the latter route. Under anaesthesia, and with the patient in the lithotomy position, the perineum and vagina are painted with an antiseptic such as weak solution of iodine, and a speculum is inserted into the vagina. The cervix is steadied with a volsellum, and a scalpel is then thrust through the *Posterior colpotomy* posterior fornix in the mid-line, over the position of the swelling. In cases in which there is doubt about the presence of pus, it may be wise, as a diagnostic measure, to use a stout exploring needle as a preliminary to this operation. When pus is present it usually escapes immediately the posterior colpotomy incision is made; but if this does not succeed, sinus forceps are used to open the cavity. A finger in the rectum will help in this manœuvre. No attempt should be made to empty the abscess by pressure from above as this may disseminate infection in the peritoneal cavity. A self-retaining drainage tube, half-an-inch in diameter, is then introduced into the cavity and the end of the tubing cut short at the lower end of the vagina. Such a drain can be easily made by slitting the end of a rubber tube for two inches; a small hole is made between, and just below, the base of the two cuts on each side. The slit ends of the tube are then invaginated and drawn through the two holes. The result is a tube with a T-shaped end, which serves excellently as a self-retaining drain. The drain is removed after one week. In a few cases a secondary abscess may form and may have to be opened anew, but on the whole the results from this treatment are satisfactory, and when the patient is seen after six months or a year, there is often little or no trace of any pelvic abnormality to be detected.

II.—PELVIC CELLULITIS IN THE MALE

219.] Pelvic cellulitis in the male is a very serious condition. Fortunately *Causation* it is rare and never occurs as a primary condition. It may result from: (1) injuries to the pelvis with extra-peritoneal haematoma which becomes infected; (2) extravasation of urine following injury to the bladder or urethra; (3) as a complication of extra-peritoneal injuries of the rectum; (4) infection of the prostatic bed after operations on

that gland; (5) more rarely as a sequel to inflammations of the prostate or seminal vesicle.

*Associated
with
fractured
pelvis*

It is very unusual for infection to occur in connexion with fractured pelvis but it may do so—and quite apart from concomitant injury to the viscera. As a rule the condition remains localized and results in an abscess, but it may spread in the cellular tissue and involve that tissue widely.

*As sequel
to extra-
peritoneal
injury*

Extra-peritoneal injury to the bladder or to the urethra above the triangular ligament is an emergency which demands urgent surgical interference. When incision and drainage are delayed, extravasation of urine occurs and may spread widely in the pelvic cellular tissue, giving rise to a serious type of cellulitis.

Injuries to the rectum are very rare in civil life, but gunshot wounds as met with in warfare may be entirely extra-peritoneal and are almost invariably associated with a serious form of spreading pelvic cellulitis.

*Sequel to
operations
on prostate*

It is surprising how seldom infection extends beyond the prostatic bed after operations on that gland. When it does so, the cellular tissue about the base of the bladder and the rectum is mostly involved.

*Sequel to
inflammation
of prostate*

Apart from operations, pelvic cellulitis may also occur as a late sequel to inflammation of the prostate or of the seminal vesicle. In these circumstances it is probably explained by rupture of a localized abscess near the surface of either organ. Quite often such an abscess is residual, and the result of an infection which has long been quiescent. Sometimes the consequences are serious and death may result from a streptococcal cellulitis which sooner or later extends to the peritoneal cavity.

*Symptoms
and signs*

Whichever of these causes may be operating, the main features are pain referred to the lower abdomen and in the rectum, pyrexia—usually 102° or 103° F.—and extreme tenderness suprapubically, per rectum, and deep in the pelvis. There may also be tenesmus, and urinary pain and irritability. Within 48 hours of the onset the abdomen is usually distended and tender, but this is due to meteorism rather than to direct infection of the peritoneum. Some cases end by the formation of a localized abscess which may be detected as a mass felt from the rectum, or which may extend upwards into either iliac fossa. In other cases the localized symptoms are soon followed by evidences of general infection, and death may take place within two or three days from acute general sepsis.

Treatment

The treatment depends largely on the cause, which should be dealt with whenever possible by the means appropriate to each case. When this cannot be done, local application of heat with sedatives may bring some relief. It is most important to watch for evidence of localized abscesses, for their incision and drainage will do more good than any other treatment.

CEREBELLAR DISEASES

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Reference may also be made to the following titles:

ATAXY	BRAIN TUMOUR
BRAIN ABSCESS	BRAIN: VASCULAR
BRAIN: REGIONAL	DISORDERS
DIAGNOSIS	

220.] The cerebellum may be involved in any of the pathological processes which affect the brain. Thus it may be the sole seat of disease in the brain; or it may be involved with other regions in a general toxic reaction, or in a condition of multiple lesions of the nervous system. Tumour or abscess may form in the cerebellum, and it may be the seat of haemorrhage or thrombosis.

In each of these circumstances, the resulting symptom-complex will be in part determined by signs of disordered function of the cerebellum, and the case may thus present itself as one of cerebellar disease. This article, however, is not concerned with cerebellar affections of this order, but only with primary diseases of the cerebellum.

1.—CEREBELLAR ATROPHIES

The essential pathological process in the different forms of primary cerebellar disease is atrophy of the nervous elements, either of nerve cells or of nerve fibres. The cerebellar atrophies are extremely rare, their aetiology and even their morbid anatomy are yet but imperfectly known or understood, and no final classification or description of them is possible in the present state of knowledge.

Numerous 'types' of cerebellar atrophy have been recorded, but some at least of these owe their supposed existence as special pathological processes to imperfect microscopic examination, or to the tendency to regard different stages of a single pathological process as separate and distinct forms of disease. These sources of error are responsible for the redundant and confusing nomenclature of the cerebellar atrophies.

In the present article no attempt will be made to perpetuate the elaborate but largely meaningless terminology with which the literature of this subject abounds, and the simplest possible form of classification will be adopted. Such of the older terms as represent known and distinct forms of atrophy will be mentioned where necessary for purposes of orientation.

Aetiology

Heredity

Exogenous factors

Abiotrophy

Morbid changes due to senescence

Nothing certain is known of the causation of either of the two principal forms of cerebellar atrophy. In some cases there is clear evidence of heredo-familial factors, but in others the operation of such factors is uncertain. But when it is remembered that the total number of cases which have been adequately studied is even now very small, it will be appreciated that lack of information on this point does not exclude hereditary influences. There is, on the other hand, no evidence in favour of an exogenous origin for any form of cerebellar atrophy. All the usual factors of this order have been invoked, such as intestinal intoxication and comparable hypothetical processes, but the weight of such evidence as there is rather favours the view that an abiotrophic process is in question: that is, an inherited defect of vitality of certain tissues which ends in their premature ageing and decay. Of course, to say that an atrophic process is an abiotrophy is not to explain it, but there are definite histological indications that a *local* process of premature old age is at work in the different forms of cerebellar atrophy.

Thus Scherer, who has provided the most precise and recent knowledge of the microscopic anatomy of cerebellar atrophy, pointed out that in the cerebellum the normal processes of senescence tend to make their first appearance in certain situations: namely, in the upper, mesial, and anterior part of the cortex where the Purkinje cells undergo degenerative change, and in the ventral and posterior parts of the central white matter. These are also the situations in which the two main types of cerebellar atrophy make their first appearance and are most severe. Further, the type of pathological change resembles that seen in normal senescence.

In this respect Scherer compares cerebellar atrophy with Pick's atrophy of the cerebrum and with Huntington's chorea, in which the cell changes are also those of premature local senility.

It is probable therefore that further knowledge will show that heredo-familial factors play some part in all the examples of cerebellar atrophy.

Morbid anatomy

As far as the cerebellum is concerned the atrophies may be divided into two categories: (1) atrophy of the cerebellar cortex, and (2) atrophy of the central white matter of the cerebellum. In the second category atrophic changes are invariably found elsewhere than in the

cerebellum proper: namely, in the pontine nuclei and fibres and in the olives, in the substantia nigra and corpus striatum, and sometimes in the cerebrum.

(1) The essential feature of atrophy of the cerebellar cortex is a degeneration and disappearance of the Purkinje cells, with the persistence of the basket formation which surrounds them. In some infantile cases there is complete and uniform sclerosis of the cerebellar convolutions and gross diminution in the size of the organ. But in the less rare adult form (delayed cortical atrophy of Marie), the lesion is maximal in, and is largely confined to, the anterior superior part of the cerebellum, where the convolutions stand up shrunken and widely separated, and give the cerebellum a characteristic appearance.

Atrophy of cerebellar cortex

It has been suggested that the atrophy in this form shows a predilection for the most primitive parts of the cerebellum (palaeo-cerebellum); but Scherer denies that this is the case, or that a system degeneration is in question. He believes that the partial degenerations which have led to this belief represent but early stages on the way to a general atrophy of Purkinje cells and after them of other cellular elements in the cortex (reduction of the molecular and granular layers). The central white matter and the dentate and roof nuclei remain intact.

(2) Atrophy of the central white matter of the cerebellum has been more closely studied and has a more striking uniformity from case to case than has cortical atrophy. It is essentially a degeneration and disappearance of the nerve fibres in the central part of the cerebellum, especially in its lower and ventral and posterior parts. A dense proliferation of glia fibres and of glia nuclei ensues upon the nerve-fibre loss. It is a primary lesion of the white matter, and, although it is not always confined to this, the loss of Purkinje cells which is sometimes seen is patchy and relatively slight. The central white matter becomes completely demyelinated and sclerosed. In addition there is loss of cells in the pontine nuclei and loss of the ponto-cerebellar fibres (middle peduncles of cerebellum), and also sclerosis of the inferior olives. Hence the name olivo-ponto-cerebellar atrophy given to this form by Marie and André-Thomas, who first described it.

Atrophy of central white matter (olivo-ponto-cerebellar atrophy)

Scherer finds that cellular changes in the substantia nigra and in the corpus striatum are constantly present in this form of cerebellar atrophy, and that where the cerebellar atrophy is most intense the nigral and striatal degenerations are less severe, and vice versa. Also focal degenerative changes may be found in the cerebral hemispheres. The clinical bearing of these extra-cerebellar lesions will be considered later. It is in connexion with this atrophy of the white matter of the cerebellum that Scherer raises the question of the possible relation between cerebellar atrophy and the focal cerebral atrophy of Pick, which latter also has the character of a local premature senile lesion.

Delayed cortical atrophy and atrophy of the central white matter are diseases of middle age and the latter half of life. They are slowly progressive, the patients succumbing to intercurrent maladies after a

Age incidence

varying number of years. But examples of cortical atrophy are reported at all periods of life. The infantile cases are usually idiots and the cerebellar lesion is but a post-mortem finding.

Symptoms

The onset is gradual in persons who may be otherwise in normal health. The atrophic process being bilaterally symmetrical, the symptoms also are bilateral and equal. The initial symptom is an increasing ataxy of gait in which all the typical cerebellar defects are present. The patient sways from side to side, rocks backwards and forwards, progresses by jerky and sometimes violent movements, and looks as though he might fall at any moment. Later the arms also become ataxic and display a gross intention tremor, dysmetria, dysdiadochokinesis and all the components of cerebellar ataxy. There develops a severe disorder of articulation, of the spaced, scanning type at first, but finally so gross as to render the patient scarcely intelligible. The head also may share in the general tremulous unsteadiness. Nystagmus is absent. It has been said that the upper limbs suffer much less severely than the lower, but this is so only in the early stages of the malady. The reflexes may remain normal, with the abdominal reflexes persisting, the tendon-jerks brisk, and the plantar responses of the flexor type.

This description applies equally to the delayed cortical type of atrophy and to the atrophy of the central white matter (olivo-ponto-cerebellar type), and in pure cases of each it is not really possible to make a clinical differentiation. However, the latter type is sometimes complicated by the development of symptoms of Parkinsonism (fixed facies, muscular rigidity, slowness of movement). The French writers attribute these symptoms to the cerebellar lesion, but Scherer has shown clearly that they depend upon the associated nigral and striatal lesions and correspond in intensity with the severity of the lesions in these structures. Similarly, the cases which show dementia are of the olivo-ponto-cerebellar type, with associated degenerative lesions in the cerebral hemispheres. Separate names have been given to these variants by French writers, but distinct pathological processes are certainly not in question and a duplication of names is undesirable.

Course and prognosis

The course is steadily progressive and is not influenced by any known mode of treatment. The subject may survive the onset by any period from two to forty or more years, and death results from some intercurrent illness.

2.—SPINO-CEREBELLAR ATAXY

The category in which the cerebellar atrophies are often considered is a clinical one—namely, that of the cerebellar or hereditary ataxies. It has been seen that ataxy is the characteristic expression of cerebellar atrophy, but it is also the predominant symptom in the heredo-familial degenerations of the spino-cerebellar and other pathways in the spinal

cord, and these so-called spino-cerebellar ataxies are commonly described under the present heading. Friedreich's ataxy also is closely allied to spino-cerebellar ataxy, but is not described in this article.

Brief reference may, however, be given to what is called spino-cerebellar ataxy, and to a form of familial ataxy which clinically closely resembles disseminated sclerosis.

In spino-cerebellar ataxy there is a general smallness of the central nervous system, especially of the brain-stem and cerebellum. There is severe degeneration of the dorsal spino-cerebellar tract and of Clarke's column of cells. The ventral spino-cerebellar tract and the posterior columns show relatively slight degenerative changes. The cerebellum presents no degenerative lesions. Clinically, the disease begins in adolescence or early adult life and shows itself by slowly developing ataxy of gait, scanning speech, nystagmus, muscular cramps and fibrillation. Optic atrophy and defective pupil reactions have also been reported.

The type resembling disseminated sclerosis is familial, but no case has come to necropsy and its morbid anatomy is therefore unknown. Clinically, the age of onset is from 35 to 45. There are ocular pareses, nystagmus, and in some cases optic atrophy. There are sensory loss and the signs of pyramidal tract involvement, disturbance of articulation, sphincter weakness, and the type of euphoria common in disseminated sclerosis. The malady, however, runs a slowly progressive course without remissions. In Ferguson and Critchley's series the malady was present in thirteen members over three generations.

*Type
resembling
disseminata
sclerosis*

Friedreich's ataxy is described in the article on SPINAL CORD DISEASES; it is also referred to in the article on ATAXY (Vol. II, p. 202).

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CEREBRAL ARTERIES, DISEASES OF

See APOPLEXY, Vol. I, p. 712;
ARTERIAL DISEASE AND DEGENERATION, Vol. II, p. 58;
and BRAIN: VASCULAR DISORDERS, Vol. II, p. 641

CEREBRAL DIPLEGIA

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Reference may also be made to the following titles:

ATHETOSIS

BIRTH PALSIES

1.—AETIOLOGY

221.] It was formerly supposed, although pathological confirmation has always been lacking, that cerebral diplegia in its various clinical forms is a form of cerebral birth palsy and is due to injuries sustained by the brain during labour and delivery. It is now known that the lesions found in the brain are not compatible with this view and can be explained only on the basis of pathological processes occurring during intra-uterine life. The macroscopic lesion is that known as atrophic sclerosis of the cerebral hemispheres, and it is suggested that agenesis of certain systems of nerve-cells may be the underlying cause.

2.—CLINICAL PICTURE

The diplegic child is frequently the first born of its mother. The birth is frequently premature (33 per cent), and may be difficult (15 per cent), or precipitate (5 per cent). Convulsions, difficult respiration, and feebleness at birth are also common. The child's head is usually of less than normal size and may even be microcephalic (of less than 17 inches in circumference). In contrast, it may be noted that when meningeal haemorrhage occurs at birth the head is larger than normal.

The presence of some cerebral lesion may be evident immediately after birth from the presence of contractures in the legs, but it is usually only during the first year of life that attention is attracted to the child's abnormality. It does not sit up at the usual time, and even in mild cases its walking is considerably delayed and abnormal.

The physical signs of cerebral diplegia are bilateral, and usually symmetrical. Several clinical types have been observed. The component symptoms are muscular weakness, spasticity, athetosis, perverse movements, contractures, increased tendon-jerks, ataxy, mental deficiency, and epileptiform fits.

*Clinical
types*

Not all these are present in every case, and the common clinical types are as follows:

*Little's
disease*

In congenital spastic paraplegia (Little's disease), the legs are rigidly extended and adducted, and may even be crossed. The foot is fully plantar-flexed and when the child is standing the heel cannot be brought to the ground. In walking, for which the child may require assistance, the legs remain crossed in the so-called 'scissors' gait. Beneath this intense spasticity there may be considerable voluntary power. In these cases the arms are normal, and frequently the mental development proceeds normally.

*Bilateral
spastic
paralysis*

Bilateral spastic paralysis is a more severe and extensive form of the above. The musculatures of speech and of deglutition and of the arms are also affected, and mental defect is common.

*Double
athetosis*

In double athetosis all the skeletal muscles are the seat of athetosis, or mobile spasm, which increases in severity when any attempt is made at voluntary movement, so that articulation and co-ordinated movement of the limbs are impossible. Here also, considerable mental defect is the rule. The physical disability tends to increase during life.

*Cerebellar
ataxy*

In the relatively uncommon cases of cerebellar ataxy there is inco-ordination of movement without muscular rigidity.

Other disorders of movement are also seen. In the most severe cases there may be profound mental deficiency (idiocy) and microcephaly.

3.—PROGNOSIS

The prognosis varies with the clinical type. It is most favourable in congenital spastic paraplegia, least favourable in athetosis and in cases with mental defect. It is of interest that some calculating prodigies are cases of cerebral diplegia. Even in the mildest cases the expectation of life seems to be less than the normal; many such patients do not reach adult life, and very few reach middle age.

Generalized epileptiform convulsions are common in cerebral diplegia, and according to some estimates are present in over 25 per cent of patients.

4.—TREATMENT

Treatment produces the most favourable results in the cases of Little's disease, that is, in those patients in whom the legs alone are affected and in whom mental development is normal. The latter factor is important as it is necessary if the patient is to co-operate in treatment. The essential element in treatment is the employment of remedial exercises, of motor training. This requires long-continued formal *Motor training* exercises and also a willingness and ability on the part of the mother to train the child. Massage has but a secondary role, but combined with passive movement is of value in the more spastic cases. In any event, these procedures cannot take the place of active exercises, a point which cannot be over-emphasized. All forms of electrical treatment are contra-indicated.

Tenotomy and other orthopaedic procedures, such as crushing of the obturator nerve in cases with strong adductor spasm, may be an *Orthopaedic procedures* essential preliminary to educational therapy, but should only be carried out when it is clear that a useful degree of voluntary power underlies the spasticity or contracture.

In general it may be said that in the presence of considerable mental defect, or of recurrent fits, double athetosis, or other disorders of movement, treatment is generally unavailing, and the subjects of these disorders commonly tend to deteriorate progressively. The cases of cerebellar ataxy are perhaps an exception to this generalization. They commonly present no mental defect, and like some cases of Little's disease may in course of time, and with due treatment, become almost normal in their motor capacity.

The administration of thyroid extract is thought to be of value in *Thyroid* some cases.

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CEREBRO-RETINAL SYNDROMES OF THE HEREDO-DEGENERATIVE TYPE

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Reference may also be made to the following titles:

BLINDNESS EPILOIA LINDAU'S DISEASE

1.—DEFINITION

222.] Recognition of the association of retinal lesions with mental defect dates back to 1861, when mental dullness in cases of retinitis pigmentosa and in the sibship of such patients was noted by Liebreich. The more dramatic fundus lesions described by Waren Tay in 1881, in infants with rapidly progressing mental degeneration and paralysis, concentrated attention on the association of fundus lesions with cerebral degeneration. Subsequent work, both clinical and pathological, has revealed a large group of cerebro-retinal syndromes, the inter-relationship of which presents a problem of considerable difficulty.

2.—CLINICAL TYPES

(1)—Tay-Sachs' Disease (Infantile Amaurotic Idiocy)

(a) *Description*

In his capacity as a general surgeon, Waren Tay had brought to him, *Historical* in 1881, a twelve-month-old baby suffering from weakness and inability to move its limbs and hold up its head. No definite paralysis could be made out. The tentative diagnosis of defective cerebral development led Tay to an ophthalmoscopic examination, which revealed in the region of the yellow spot in each eye 'a conspicuous, tolerably defined, large white patch, more or less circular in outline and showing at its centre a brownish-red circular spot, contrasting strongly with the white patch surrounding it'. Four and a half months later the macular appearance was unchanged but the discs had become atrophic and the child had become more helpless. Subsequently Tay was able to observe three more cases in the same family, and to report that in the three earlier cases death had occurred before the age of two years. Independent reports of similar cases were published by Goldzieher and by Magnus in 1885; in the same year Knapp described a further case, the post-mortem findings of which were reported by Bernard Sachs in 1887. Kingdon, in 1892, summarized the then existing knowledge on the subject, and stressed the pathognomonic significance of the macular appearance in this 'rare, fatal disease of infancy'. In 1894 Carter drew attention to the racial predilection of the disease, and in 1896 Sachs named the condition amaurotic family idiocy. The eponym Tay-Sachs' disease was suggested by Higier in 1901.

The disease was originally regarded as confined to Jews, but Slome *Aetiology* (1933) traced eighteen undoubtedly authentic non-Jewish cases among the 200 or so reported in the literature. A greater incidence in Jews, however, remains undisputed. Cases have been reported from most parts of the world, and the affection has been noted amongst natives of Japan. Syphilis, tuberculosis, and neurotic taints are of no signifi-

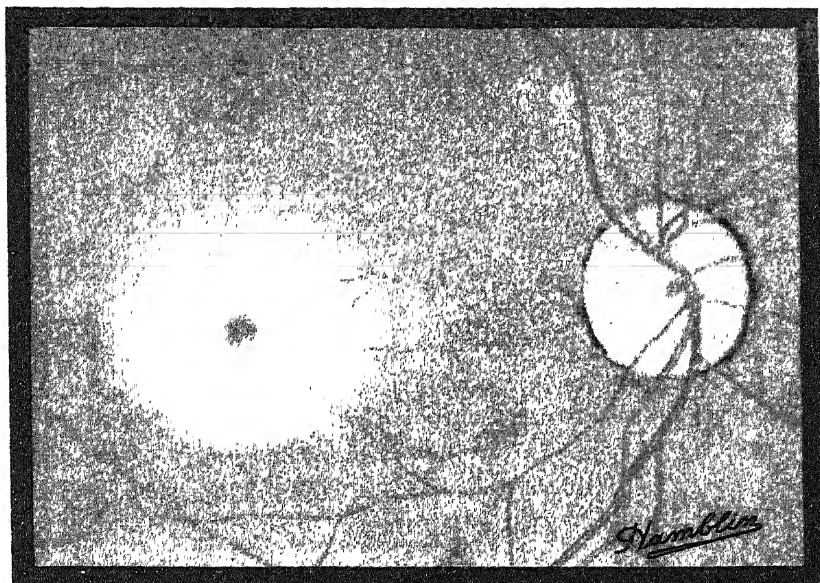
cance in its causation; histological studies have proved the complete absence of any inflammatory reactions. The recessive character of the condition is brought out by the occurrence of 111 cases in 69 families containing two or more members, and by the presence of consanguinity in the parents in more than 50 per cent (Slome). In one family the disease occurred in one of twin infants. The affection has been noted in collateral branches of one family.

*Morbid
anatomy*

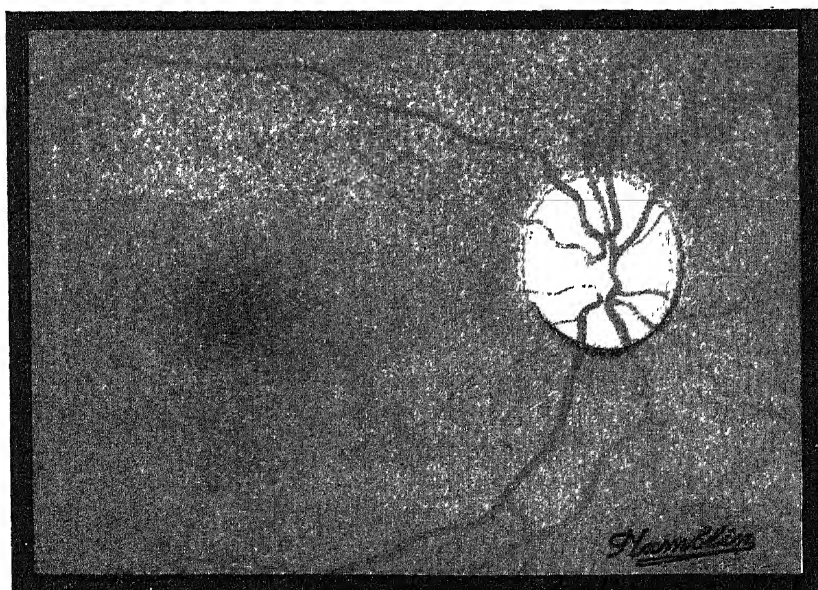
The brain becomes much firmer in consistency, assuming rubbery hardness; the sulci are widened, leading to greater prominence of the gyri. The histological changes are striking and unique; the nerve-cells, dendrites, and less commonly the axis cylinders show generalized swelling, and there is also diffuse gliosis. The characteristic lesions in the nerve-cells consist of changes in the contour, structure, and chemical properties of the cell content. The normal pyramidal outline of the cell is changed to a rounded or pear-shaped contour, the cells being distinctly enlarged. The Nissl's bodies in the nerve-cells are markedly reduced or completely absent, showing a fibrillar network filled with finely granular substance. In more advanced cases the network may be lost and the cell filled with debris. The nucleus is displaced towards the periphery and stains poorly on account of disintegration; ultimately it disappears, together with the rest of the cell contents. Fat stains show the granules in the cells to be of the nature of a prelipoid lecithin-like material. These structural and chemical changes are seen throughout the whole central nervous system, including the cerebellum and retinae, the ganglion cells of the latter being heavily involved. In the subcortex the outstanding features are widespread gliosis and disintegration of the myelin, leading to exposure of naked axis cylinders and accumulation of fat.

Symptoms

Few diseases are so constant in appearances and course. A previously healthy infant becomes listless and apathetic, and with increasing weakness is no longer able to sit up. The head falls backwards if unsupported, and when lying on its back the infant cannot turn onto either side. Objects placed in its hands are grasped but feebly and soon dropped. The muscles are flaccid but sometimes spastic. The reflexes are generally normal, but are sometimes either slightly sub-normal or exaggerated. Occasionally the infant is unusually sensitive to sound and starts at the least noise. Convulsions may occur. Bronchial attacks and gastro-intestinal disturbances are frequent. Deterioration steadily advances until the child becomes completely helpless and markedly emaciated. The most characteristic changes are ophthalmoscopic (see Plate II, A). The macular area appears as a cherry-red spot on a milky background extending over a circular area of more than two disc diameters. The periphery of the fundus is generally normal, though pigmentary disturbances have been described. In the early stages the discs are normal; later they are atrophic. Purposeless, roving movements of the blind eyes set in. The blind, paralysed, imbecile, marasmic child usually dies before reaching the



A



B

Fundus appearances: A.—In Tay-Sachs' disease.
 B.—In Batten-Mayou disease

PLATE II

[To face p. 32

age of two years, and only exceptionally survives after the third year.

(b) Relation to Niemann-Pick Disease

The observation in 1927 by R. Hamburger of the occurrence of Tay-Sachs' disease in a case of Niemann-Pick disease, and Bielschowsky's histological study of the case a year later, have drawn attention to this association, of which a number of instances have since been reported. The association had been previously noted in 1916 by Knox, Wahl, and Schmeisser. Earlier histologists had stressed the fact that though the cells in Tay-Sachs' disease may be filled with lipid, the fibres arising from the cells may be normal, and argued that the lipid does not represent the products of nerve-cell degeneration, but a faulty general metabolism with fat deposition in nervous tissue. In Niemann-Pick disease there is widespread lipid histiocytosis, most prominent in the spleen and liver, but also in other organs such as the bone marrow, adrenals, and lymph nodes. The similarity in the chemical reaction of the abnormal cell-contents in the liver in Niemann-Pick disease and of that in the brain in Tay-Sachs' disease is very striking.

Bielschowsky, Spielmeyer, Kufs, and others regarded Tay-Sachs' disease as the localized neurological expression of a metabolic disorder; Schaffer, however, considered that only the Niemann-Pick disease was the result of metabolic disorder and that Tay-Sachs' disease was due to a lipid degeneration of the nervous tissue, the fat originating locally. Rintelen supported this latter view on the ground that in a case of Niemann-Pick disease with the cherry-red spot at the macula the optic nerve was histologically normal. Van Bogaert's observation of cases of Tay-Sachs' and of Niemann-Pick diseases in the same family is, however, strong evidence in favour of the essential unity in the pathology of these affections.

(2)—Batten-Mayou Disease (Juvenile Amaurotic Idiocy)

In 1903, F. E. Batten drew attention to the occurrence of 'cerebral *Historical* degeneration with symmetrical changes in the maculae in two members of a family'. His patient, aged seven, had been healthy till a year before, and a sister had developed similar symptoms at the age of five. The patient showed 'peppered pigmentary changes all over the retina . . . at each macula there was a reddish-black spot . . . irregular and not round . . . the region immediately surrounding the dark spot was paler than the rest of the fundus, and more atrophic looking'. Cerebral degeneration was shown by mental changes, feeble kneejerks, and an extensor plantar reflex. The question of the relation of these cases to those of Tay-Sachs' disease was raised. A year later Mayou demonstrated three similar cases in one sibship. H. Vogt in 1905 independently reported two cases in one family, and on an exhaustive survey of the literature (omitting, however, the cases of

Batten and Mayou, but including two suggestive cases of Freud in 1893), aimed at establishing the condition as a variant of the Tay-Sachs' disease, advancing histological evidence in 1907 to support his view. In 1906 Spielmeyer, also independently, described four cases, and emphasized the association with Tay-Sachs' disease; his cases were studied histologically by Stock in 1908. In Vogt's cases the discs were described as pale; in Spielmeyer's the fundi showed a picture simulating retinitis pigmentosa. Another early observer was Oatman (1907) and the names Batten-Mayou disease, Vogt-Spielmeyer disease, Spielmeyer-Stock disease, Oatman's disease, cerebro-macular degeneration, cerebro-retinal degeneration, and juvenile amaurotic idiocy are all in current use.

Aetiology

Syphilis, which early observers regarded as a possible factor in the aetiology of the Batten-Mayou disease, has no significance. The histology of the condition excludes an inflammatory cause. The work of Sjögren clearly establishes the condition as an heredo-degeneration of a simple, recessive type. The family history shows no features that are statistically significant except the great frequency of consanguinity among the parents. In contrast to Tay-Sachs' disease there is no racial predilection for Jews.

Morbid anatomy, comparison with Tay-Sachs' disease

The morbid changes are essentially the same as observed in Tay-Sachs' disease. The main differences are:

1. In the retina degenerative changes are less extensive in the ganglion cells than in Tay-Sachs' disease, and the rod and cone layer which is but little affected in Tay-Sachs' disease is completely destroyed.

2. There is greater variation in the intensity of degenerative changes in the Batten-Mayou disease. Changes in the cerebellum, basal ganglia, and medulla may be slight.

3. Staining reactions for fats in the ganglion cells give different results. In Tay-Sachs' disease prelipoid lecithin-like material is present; in the Batten-Mayou disease the fats are of a simpler form, approaching the constitution of neutral fats.

The significance of these variations in essentially similar histological pictures is a matter of dispute.

Symptoms

Commonly there is normal development till the age of five to eight years. The first sign of the affection is rapidly-failing vision, generally going on to almost complete blindness within two years. During this stage psychic disturbances arise, and epileptic attacks, which generally occur later, may also develop. After the onset of the blindness and of increasing mental dullness, disturbances in speech appear; these too are progressive, ultimately leading to practically unintelligible articulation. Neurological signs are late; difficulty in walking is followed by contracture at the joints and a kyphotic back with the head protruded forward. Increasing weakness ultimately leads to complete helplessness. The muscles become rigid, but clonus, tremor, and athetosis are absent. In some cases Rombergism develops towards the terminal stages, and, though there is increasing spasticity, changes

in the reflexes are not always present. The neurological signs are in fact essentially of extra-pyramidal character. Towards the end the child is paralysed, wasted, incontinent, bedridden, blind, and completely demented. Death occurs between 14 and 18 years of age, generally from some intercurrent affection; occasionally life is prolonged beyond the age of 25.

Ophthalmoscopically (see Plate II, B) fine pigmentary changes in the fundus are probably the first signs; optic atrophy and narrowing of the vessels appear later. Macular changes in the form of pigmentary disturbances are more emphasized by British than by continental observers. Atrophy of the retina, sometimes with pigmentary degeneration characteristic of 'retinitis pigmentosa', but differing from classical retinitis pigmentosa in that the central areas are affected simultaneously with the periphery, is present in the fully-developed case. Other ocular signs which may be present are squint, divergent or convergent, post-cortical cataract, and fine vitreous opacities. Irregular nystagmus is almost constant in the terminal stages.

Ophthalmoscopic appearances

(3)—Late Infantile Cerebro-Retinal Degenerations

Under the name 'late infantile familial amaurotic idiocy with cerebellar symptoms' Bielschowsky described an intermediate group between Tay-Sachs' disease and Batten-Mayou disease. The affection begins in the fourth year; the eye signs are late and consist of optic atrophy (without a macular lesion). Histologically the appearances are similar to those seen in the two other affections. Whether these cases represent a separate entity is doubtful; not all cases of Batten-Mayou disease begin at the age of six. (In Torrance's cases and in one of Vogt's cases it began in the second year; in one of F. E. Batten's in the third year.) Furthermore not all cases of Tay-Sachs' disease end fatally before the end of the second or even third year. That Tay-Sachs' disease may set in relatively late is suggested by the case studied by Greenfield and Nevin, in which the affection appears to have come on at the age of two, the child dying from an intercurrent affection at the age of two years and eleven months.

(4)—Late Juvenile and Adult Cerebro-Retinal Degenerations

Walter reported on a family in which three members were affected with idiocy and nervous lesions, but without any eye changes. The youngest died at 23, the others were still alive at 24 and 29 years of age. Histologically the brain of the deceased member of the family showed changes similar to those in Tay-Sachs' disease. Kufs reported two 'late' cases, one beginning at 26, and ending fatally at 38, the other extending from 42 to 59 years. These cases too had no eye changes. A late juvenile case with onset at 18 and death at 26 was reported by Meyer, whose diagnosis was confirmed histologically.

(5)—Anomalous Types

These types include cases which have been described in the literature but whose authenticity has not been satisfactorily established. Actually there is far more evidence for the existence, as a genuine clinical entity, of type (c) below, than for that of types (a) and (b).

(a) *Tay-Sachs' Disease without Typical Macular Appearance*

A number of earlier writers reported such cases. No case has, however, been verified post mortem, and the absence of this pathognomonic sign has not been finally proved. The least unconvincing case comes from Bertrand and van Bogaert (1934).

(b) *Batten-Mayou Disease with Cherry-Red Spot*

Torrance (1921) collected eleven cases in which he considered a cherry-red spot to have been present, but a none too hypercritical study of the original papers disposes of these cases. Thus the case of Gordon was one of the Laurence-Moon-Biedl syndrome (see p. 37), and the other cases are for other reasons equally inadmissible.

(c) *Amaurotic Idiocy without Amaurosis*

Kufs, drawing on his own cases of 'late amaurotic idiocy' and on those of Walter, believes that eye changes are not an essential component of 'amaurotic idiocy'.

3.—INTER-RELATION OF THE VARIOUS CLINICAL TYPES

It is clear that the histological picture of Tay-Sachs' disease forms the basis of a number of different affections. Clinically there are the sharply cut Tay-Sachs' disease and Batten-Mayou disease, and in both groups the age distribution is fairly rigid. Cases departing from these in age distribution occur; but to regard them as intermediate between the infantile and the juvenile cases (Tay-Sachs' disease and Batten-Mayou disease respectively) on the one hand, and the ill-defined adult type on the other, is not warranted on the available evidence and only confuses the issue. Sjögren in his exhaustive study of fifty cases of Batten-Mayou disease could not find any case of Tay-Sachs' disease in any of his families—as one would have expected to have found if the conditions were genotypically identical. The only example of the occurrence of Tay-Sachs' and the Batten-Mayou disease in the same family was recorded by Higier (1906).

4.—ALLIED CONDITIONS

(1)—**Familial Macular Degeneration with Dementia but no Paralysis**

Nettleship in 1908 reported the case of a woman aged 48 with defective vision since infancy and macular changes. She was feeble-minded,

and of two members of her family who had bad sight, one was an idiot. Some of the cases reported as cerebro-macular degeneration probably belong to this group rather than to the more serious affection represented by the Batten-Mayou diseases. Leber in 1916 spoke of a generalized retinal dystrophy associated with dementia but without paralysis, beginning early in life—probably a variant of this condition.

(2)—The Laurence-Moon-Biedl Syndrome

Typically the fundi show a pigmentary degeneration reminiscent of retinitis pigmentosa, but the ophthalmoscopic variations observed are similar to those seen in the Batten-Mayou disease. As no case of the syndrome has yet come to histological examination (Cockayne, Krestin, and Sorsby, 1935), the possible relationship remains hypothetical and dubious. See PITUITARY GLAND DISEASES.

(3)—Familial Macular Degeneration without Paralytic or Psychic Disturbances

R. D. Batten (1897) drew attention to the familial occurrence of macular changes coming on at puberty. Subsequent observations have shown at least two fairly clearly defined types: in one the familial lesion makes its appearance at the time of the second dentition, in the other at puberty (Stargardt). Transitional forms from this affection to macular degeneration with psychic disturbances and the Batten-Mayou disease have not been observed.

(4)—Other Familial Cerebro-Retinal Syndromes

Retinal lesions are also seen in tuberous sclerosis (see EPILOIA) and in the Lindau syndrome (see LINDAU'S DISEASE). They are not likely to give rise to difficulty in the differential diagnosis from the group discussed here. Optic atrophy occurs in Schilder's disease, Pelizaeus-Merzbacher disease, and other forms of familial demyelinating affections, as also in ill-defined groups of familial mental deficiency and familial psychoses. Optic atrophy is not infrequent in the Marie type of Friedreich's ataxy (see SPINAL CORD DISEASES).

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CEREBROSPINAL FEVER

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Reference may also be made to the following titles:

CARRIERS IN INFECTIVE DISEASE	CEREBROSPINAL FLUID MENINGITIS
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1.—DEFINITION

223.] Cerebrospinal fever is an acute infectious disease, occurring sporadically and in epidemics, caused by the meningococcus, and characterized pathologically by purulent inflammation of the meninges of the brain and spinal cord.

Vieusseux first described the disease in 1805 from observation of an *Historical* outbreak in Geneva. Of its previous history nothing is known. In 1806

Danielson and Mann described an epidemic in America, and in 1811 Elisha North gave a full account of the known epidemics. There is no doubt that by this time epidemics had occurred in most countries, but the recognition of the disease as an entity was very slow. Gee and Barlow (1878) separated posterior basic meningitis of infants from tuberculous meningitis.

2.—AETIOLOGY

Cerebrospinal fever occurs both in epidemic and sporadic forms. The epidemics tend to be localized in area and to last for a few months, and subsequently sporadic cases occur in the same district.

Geographical distribution

The disease exists in all parts of the world and epidemics with high mortality have been reported alike in the tropics and in temperate zones.

Incidence

In the present century there have been many severe recorded epidemics. In New York in 1904–5 there were 6,755 cases with 3,455 deaths. In 1907 there were 998 cases in Glasgow with 715 deaths. Early in the Great War the disease was carried to England by the Canadian troops and large outbreaks occurred among the recruits and spread to the civilian population. During all the years of the War there were large numbers of cases with a mortality of about 60 per cent. In the epidemic in Yorkshire in 1932 there were 2,095 recorded cases and 1,199 deaths.

Seasonal incidence

In temperate zones, such as Great Britain, it is most prevalent in the first five months of the year. Epidemics tend to die down between July and December. It is possible that this is due not so much to climatic variations as to deficient ventilation and overcrowding, and perhaps to the prevalence of catarrhal infection, which assist in spreading the meningococcus.

Age and sex incidence

The disease especially affects children, but special factors may result in epidemics among adults. About 50 per cent of cases occur in children under five years of age, though it is very rare in the first three months of life, and nearly 75 per cent in children under ten years. It seldom occurs after sixty years of age. The sexes are equally liable. This age incidence may be entirely altered by special factors, as in the numerous epidemics among recruits living in overcrowded barracks and exposed to excessive fatigue and other depressing conditions.

Mode of spread of infection

Epidemics in civilian life are characterized by the irregularity of their spread and it is rare for more than one case to occur in a household. Animals are not liable to infection, except monkeys under experimental conditions, and consequently infection must be spread solely by human beings. Evidence has accumulated that the spread of infection is due to the so-called 'carriers'.

Carriers

Carriers harbour the meningococcus in the nasopharynx and the disease is spread from them by droplet infection. There is no evidence that the fomites are infectious and, indeed, it is improbable, since the meningococcus is a delicate organism which dies rapidly when separated from mucus, and is easily overgrown by other organisms.

Carriers are of two types, temporary and chronic. Temporary carriers are those who harbour the meningococcus for a certain period after an attack, a period arbitrarily accepted as not exceeding a few weeks. As these carriers are usually under observation the spread of infection from them is not a serious factor. Chronic carriers may be those who harbour the organism for prolonged periods after an attack, but the majority of chronic carriers, who constitute the special danger, have never had cerebrospinal fever. It appears that their susceptibility is low since it is very rare for a chronic carrier to contract the disease. Extensive investigations of the carrier problem were carried out in Great Britain during the War, especially by Glover, large numbers of persons being examined for the presence of meningococci in the nasopharynx. It is remarkable how high the carrier rate may be. In a healthy population with only a rare sporadic case the carrier rate is below 5 per cent. It rises with the increase of sporadic cases, but the danger of an epidemic does not occur until the carrier rate is in the neighbourhood of 20 per cent. The influence of overcrowding is very well marked. It was found among recruits in barracks that when the beds were three feet apart the carrier rate was below 5 per cent, when only one foot apart the carrier rate increased to 20 per cent, and when nine inches apart to nearly 30 per cent (Glover). The amount of cubic space appears to be only an incidental factor, the important factor being the distance between the beds. Fatigue may be a factor contributing to infection, but in many campaigns in which troops have been exposed to exhausting conditions in the open, there have been no outbreaks of cerebrospinal fever. Catarrhal infection, coughs, and colds probably increase the risk of droplet infection, by causing sneezing and coughing, and by rendering the nasopharynx more liable to infection.

3.—BACTERIOLOGY

The *Diplococcus intracellularis meningitidis*, generally known as the meningococcus, was discovered by Weichselbaum in 1887. In 1897 Still isolated a diplococcus from posterior basic meningitis which has been identified as the same organism.

The organism is a diplococcus; in the cerebrospinal fluid and in pus, most, but not all, of the cocci are intracellular, within leucocytes. It is negative to Gram's stain. Vitality is slight outside the body, and the meningococcus does not grow readily on ordinary media. It can be cultivated on serum-agar and certain other media, but frequent subcultures are necessary. Cultures tend to produce involution forms, the cocci being swollen and staining badly. Exotoxins are not produced in any medium, but the living cocci contains endotoxins.

*Characters of
the meningo-
coccus*

By agglutination and by agglutinin-absorption tests with antisera prepared by inoculating animals with various strains, Gordon separated four types of meningococci, known as I, II, III, and IV. Types I and II occur with about equal frequency, forming 90 per cent of all strains

*Types of
meningococci*

isolated from human beings. These types tend especially to affect the meninges. Types III and IV are much rarer and are usually isolated from cases of meningococcal septicaemia. Dopter divided the strains into two groups, type A which he called meningococcus and which corresponds to Gordon's types I and III, and type B which he called parameningococcus and which corresponds to Gordon's types II and IV. Only one type is present in an infected human being and the same strain is present in the nasopharynx and cerebrospinal fluid. The patient's serum contains agglutinins to the infecting strain by the fourth day of illness.

Animal infection

Animals in general are not susceptible to meningococcal infection, but lesions similar to those in human beings can be produced in monkeys by intraspinal injection of cultures or of cerebrospinal fluid from a human case.

Production of antiserum

An antiserum can be produced in horses and monkeys by the intravenous injection of cultures, and this antiserum is of value in the treatment of the disease in human subjects. Unfortunately, an antiserum is of value only for the type of meningococcus used in its preparation. Thus type I antiserum is not efficacious against type II infection. Further, the various types differ in the strengths of the antisera which they produce, type II antiserum being of much lower valency than that of type I. This specificity unavoidably militates against the value of antisera in the treatment of human disease and accounts for the somewhat disappointing results.

It may be difficult to recognize the meningococcus by its morphological or cultural characteristics, and the identity of a culture should always be confirmed by agglutination with antisera.

Isolation of meningococcus

The organism is isolated from the human body in various ways:

1. From the nasopharynx. A fleck of mucus is removed from the upper nasopharynx and cultures are made from it. A curved swab must be used for this purpose in order to avoid contamination with saliva, since the meningococcus is rapidly overgrown by salivary streptococci and pneumococci. The organism can thus be isolated from carriers, either temporary or chronic, but it is rarely found during the active stages of the disease.

2. From the blood. Positive results are obtained only in the early stages of the attack, and in not more than 25 per cent of cases.

3. From the cerebrospinal fluid. Cultures are prepared in the usual manner. The percentage of positive results is increased by incubating the cerebrospinal fluid for twenty-four hours before making the cultures.

4.—MORBID ANATOMY

Meninges

The general characteristic is a suppurative inflammation of the pia-arachnoid at the base of the brain, but in the acute septicaemic form there is no meningeal or cerebral lesion. In acute fulminating cases

active hyperaemia of the arachnoid may be the only obvious change. In cases of longer duration the pia-arachnoid is injected, and purulent exudation is present in the subarachnoid spaces. The exudation is most marked at the base of the brain and over the upper surface of the cerebellum. On the cortex there is often much lymph, especially in the larger depressions, and not uncommonly there is pus over the frontal and anterior parietal portions. In severe cases pus may extend over the whole brain and cerebellum. The brain substance is soft and pink, and there may be foci of haemorrhage. The cranial nerves are often inflamed. The ventricles are distended with fluid and often with pus. Microscopically there is infiltration along the blood-vessels and other channels. *Brain*

The spinal cord is always involved, especially on the posterior surface and in the dorsal and lumbar regions, and the exudation may surround the entire cord and extend into the nerve-roots. *Cord*

In more chronic cases the meninges are thickened, the exudation is in various stages of organization, and adhesions are present in the subarachnoid spaces. The resulting obstruction, together with closure of the foramen of Magendie, results in dilatation of the fourth and lateral ventricles with clear or turbid fluid. *Meninges*
Ventricles

The other organs show little change, but the spleen is occasionally enlarged. *Abdominal organs*

The initial infection is undoubtedly in the nasopharynx, but there is considerable difference of opinion as to how the meningococci reach the meninges from this site. There are two principal possibilities. First, there may be direct spread from the nasopharynx to the meninges by the lymphatics. This path may be straight through the cribriform plate or it may be irregular through the sphenoidal and ethmoidal sinuses. There is no doubt that these sinuses are often full of pus, and the bone inflamed. Secondly, the path may be through an infection of the blood. This view presumes an initial septicaemia with subsequent localization in the meninges. There is no doubt that there is frequently a short stage during which the cocci may be isolated from blood cultures. In most cases this may be regarded more correctly as a transient blood infection rather than a true septicaemia, but a true meningococcal septicaemia may occur without any subsequent meningeal infection as in certain rapid, fulminating cases and in some chronic septic forms in which, for example, malignant endocarditis may be found (see p. 46). It is generally believed that the usual path is haematogenous, but this does not exclude the possibility that there may sometimes be a direct infection through the lymphatics. *The path of infection*

5.—CLINICAL PICTURE

In cases in which the source and time of infection are reasonably certain, the incubation period has been found to be short, and it is probably from one to four or five days. *Incubation period*

The clinical manifestations vary to an extraordinary degree. Certain types are commonly distinguished to which, although many intermediate forms occur, the majority of cases can be referred.

(1)—The Ordinary Form

Onset

The onset is usually sudden with headache, vomiting, rigors, and, in children, convulsions. The temperature is 101° or 102° F. These symptoms are sometimes regarded as pre-meningitic and even before this sudden onset there may be a short stage of premonitory symptoms such as headache and loss of appetite. Temporary improvement occasionally follows the onset, but in most cases there is rapid progress to a painful stiffness of the neck muscles, head retraction, and general irritability including restlessness, photophobia, and sensitiveness to noises. The occurrence of an initial pharyngitis or local infection of the nose and throat is still in dispute. The characteristic symptoms usually take from one to five days to develop, and remain at their height for one to three weeks.

Motor symptoms

The motor symptoms are characteristic, the most important being as follows:

Head retraction

Head retraction varies in degree and is due to spasm of the neck muscles, which often are hard and tense even if the retraction is not well marked. In infants the muscles of the back are also often involved, resulting in the condition called opisthotonos. See Plate III.

Tests for muscular rigidity

There are certain tests of muscular rigidity which are of special value. (a) Kernig's sign is rarely absent, but its presence is not pathognomonic, and it is not always easy to determine in a restless subject. (b) Brudzinski's neck sign: with the patient lying on the back the hand is placed on the occiput, and on sharply flexing the head, to bring the chin on to the chest, flexion takes place at the knees and hips. This is a valuable sign of meningitis and is often of great use in doubtful cases. (c) Brudzinski's leg sign: if one leg be flexed the same movement occurs in the opposite leg. This test is somewhat difficult to estimate.

Tremor

Tremor of the muscles is common. There may be twitching, gradually increasing to clonic or tonic spasms. The face muscles are frequently affected by spasms or paralysis.

Ocular symptoms

Ocular symptoms are important. Strabismus is frequently present. The pupils are usually dilated from irritation of the sympathetic, but may be contracted in severe forms, and inequality and sluggish reactions are common. Ptosis, nystagmus, hippus, and conjunctivitis are occasionally present. Photophobia is not so common as in tuberculous meningitis. Optic neuritis is distinctly rare, which is contrary to what would be expected.

Reflexes

The deep reflexes are usually increased but may be absent, and all reflexes may vary rapidly during the course of the illness. The plantar response is commonly flexor, but is extensor in about 10 per cent of cases. Monoplegia and hemiplegia of any type may develop.

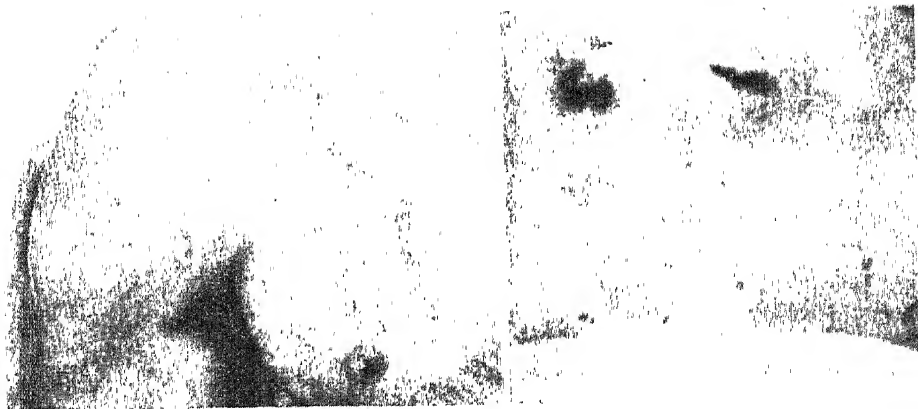


Head retraction and opisthotonos in a child; note also spasm of muscles of extremities
[By kind permission of Dr. Otto Leyton]

PLATE III



A



B

C

A.—Herpes on the face. B.—Macular eruption; when the spots are of larger size, they constitute the erythematous eruption. C.—Eruption showing petechial spots of various sizes, and also larger irregular haemorrhages

PLATE IV

Headache is often very severe and is usually occipital. Pain may extend along the spine and into the limbs. General hyperaesthesia may occur. *Sensory symptoms*

Restlessness and delirium are early symptoms, or there may be an initial coma. Delirium is often violent and there is sometimes furious mania, but, in spite of this, recovery may take place. *Psychical symptoms*

Eruptions may be considered in three groups (see Plate IV): *Eruptions*

(1) Haemorrhagic rashes occur with a frequency which varies greatly in different epidemics. It is often less than 20 per cent, but may rise as high as 60 per cent. The rash appears early, either on the first or second day, and it may be petechial, constituting the so-called spotted fever, or purpuric with extensive haemorrhages.

(2) Herpes labialis occurs in 25 to 50 per cent of cases. The onset is not before the fourth or fifth day. It is commoner in cerebrospinal fever than in any other condition except pneumonia. Herpes zoster is rare.

(3) An erythematous rash may resemble the spots of typhoid and appear on the first or second day of illness. Sometimes there is an extensive erythema. Urticaria is rare.

Deafness is not uncommon and may persist after recovery. *Deafness*

The temperature is irregular and variable and there is not any characteristic course. At the onset it is raised to about 101° or 102° F., and subsequently it may rise and fall irregularly. Remissions and intermissions are common and may correspond to exacerbations of the inflammation. The pulse is moderately accelerated, but is often slow in proportion to the temperature and is frequently irregular. The respirations are increased in frequency only with pulmonary complications, but towards the termination there may be Cheyne-Stokes breathing. The tongue is furred and the bowels are constipated. Albuminuria is unusual. Vomiting is very common at the onset and is of the cerebral type. It may continue, or may subside after the first few days. *General symptoms*

Polymorphonuclear leucocytosis is almost invariably present, the number usually being between 25,000 and 50,000 per c.mm., but leucocytosis may be absent in fulminating cases. *The blood*

(2)—The Fulminating Form

The onset in this type is abrupt with headaches, vomiting, severe rigors, feeble slow pulse, and rapid collapse. There is usually a purpuric eruption. The temperature may be high or low. Coma develops rapidly, and death may take place within a few hours. The cerebrospinal fluid may be clear and not contain meningococci, and meningeal symptoms may be slight or absent, but at autopsy meningitis may be found. Haemorrhage into the medulla of the adrenal gland is frequent.

(3)—Mild and Abortive Forms

Mild cases may occur in which the initial symptoms are slight although of the same character as in the more severe forms. The illness may last only a few days and the true cause is rarely diagnosed except during an epidemic. Other cases are more correctly described as abortive, and in *Mild cases*
Abortive cases

these there may be severe symptoms including delirium at the onset, but in the course of a few days they subside and the patient recovers. In some of these cases there is undoubtedly a transient meningococcal septicaemia without the development of meningitis.

(4)—Chronic Forms

Chronic cerebrospinal fever may develop from ordinary attacks which are protracted, or in which recrudescences take place over many months. The clinical features depend on the organization of lymph and the formation of adhesions in the subarachnoid space as described on page 43. Frequently there is closure of the foramina of Magendie and Luschka and the ventricles are distended with clear or turbid fluid, constituting 'closed ventricular meningitis' or internal hydrocephalus. The nervous manifestations consequently are very varied. There is extreme emaciation with disturbances of pulse and respiration. Death is usual and complete recovery is impossible.

(5)—Meningococcal Septicaemia

There are two clinical groups in which meningococci may be present in the blood, first the fulminating form referred to above, and secondly a form without meningeal symptoms. The latter corresponds to the abortive form mentioned above, but occasionally the blood-infection may continue for weeks or months with few symptoms other than headaches and malaise. In chronic septicaemia malignant endocarditis may arise and make the prognosis more serious.

(6)—Posterior Basic Meningitis of Infants

This is a chronic encysted meningococcal meningitis occurring in young infants, and its special characteristics are determined by the age of the patient and the chronicity of the disease. The ordinary acute cerebrospinal fever may also occur in young children, and run its usual course. Of the cases which can be classified as posterior basic meningitis more than half occur under six months of age.

In chronic meningitis the foramina of Magendie and Luschka may be obstructed, resulting in distension of the ventricles or internal hydrocephalus. The spinal subarachnoid space may also be blocked by fibrin or later by adhesions. Such blocking tends to occur in infants, in whom the space is naturally small. As a result of blockage of the subarachnoid space, lumbar puncture may give a 'dry tap'; in other cases a little clear fluid may be obtained which is free from cocci, contains a predominance of lymphocytes, and has a normal sugar content; or Froin's syndrome may be found (see p. 64).

*Lumbar
puncture*

Onset

The onset may be acute with rapid development of head retraction, the disease later passing into the chronic stages; but in many cases the onset may be insidious, the symptoms not characteristic, and the diagnosis difficult. There may be some tremor of the limbs and bulging of the anterior fontanelle, but it may be several days or even two or three

weeks before the appearance of convulsions and retraction of the head. Probably by this time hydrocephalus has developed.

Certain special features may be mentioned. Long duration is an essential feature of the characteristic posterior basic meningitis. Rashes are rare; this is in accordance with the observation that rashes are usually associated with an acute course. Head retraction and opisthotonos are marked, and the limbs, fingers, and toes may be in the position of tetany; this is due partly to the greater flexibility of the spinal column at this age. Loss of vision apparently occurs without optic neuritis. *Clinical picture*

Sequelae are usually present in non-fatal cases, including deafness and hence, owing to the age of the patient, deaf-mutism; and also blindness, mental deficiency, and general spasticity of the extremities due to the presence of hydrocephalus. *Sequelae*

Prognosis is serious, and about 50 per cent of the patients die; complete recovery occurs in about 15 per cent; and 35 per cent are left with various severe sequelae. *Prognosis*

6.—CEREBROSPINAL FLUID

The fluid may be clear for the first twenty-four hours after the onset of symptoms, although the pressure is already high and cocci are present. Of the cells lymphocytes predominate. In ordinary cases the fluid rapidly assumes characteristic features. The amount is greatly increased and the pressure is abnormally high, reaching as much as 250 to 300 mm. as against a normal figure of about 120 mm. The fluid is turbid or purulent with an increased protein content, and polymorphonuclear leucocytes become numerous. Meningococci are present in considerable numbers and are mainly intracellular (in the polynuclear cells), but there are usually a few extracellular cocci. In severe cases the cocci may be very scanty, even when the fluid is purulent, and it has been suggested that this is due to lysis. Dextrose is absent, the cause of this being still obscure, but it may have been fermented by the meningococci or destroyed by the action of leucocytes. Mixed infections are rare, but occasionally pneumococci are present. The condition of the fluid in the chronic forms and posterior basic meningitis has already been described. See also CEREBROSPINAL FLUID (p. 52).

7.—COMPLICATIONS AND SEQUELAE

Involvement of the nervous system is typical of the disease. Extension of the inflammation along the cranial and spinal nerves may lead to various spasms and paralyses, the facial nerve being most commonly affected. Internal hydrocephalus develops in the chronic forms with the manifestations which have already been described. *Nervous system*

- Ear* Deafness is common. It often develops early, is bilateral and permanent, and is probably due to affections of the internal ear and auditory nerves. Otitis media is not uncommon, but is not the usual cause of the deafness. When deafness occurs in young children, it results in deaf-mutism.
- Arthritis* Arthritis is a well-recognized complication, varying greatly in frequency in different epidemics, being most common in cases in which a haemorrhagic rash has been present. Rolleston gave an incidence of 5 per cent in one epidemic. One or many joints may be affected. Suppuration is very rare and the prognosis is good.
- Eye* The rarity of optic neuritis has often been emphasized, but some degree of swelling is probably present in about 10 per cent of cases. It is very rarely present with internal hydrocephalus and the explanation is given that when internal hydrocephalus is absolute, there is no fluid in the subarachnoid space to distend the vaginal sheath of the optic nerve.
- Various complications* Pneumonia is not a common complication in most epidemics. Certain of the cases are probably due to the meningococcus. Orchitis, epididymitis, and parotitis are occasionally observed. Pericarditis is sometimes found at autopsy but is rarely diagnosed during life.
- Coryza and catarrh* There is considerable difference of opinion as to the incidence of coryza and nasopharyngeal catarrh and their relation to the development of the disease. Some authorities believe that it is almost a constant symptom at the onset, attributable to the presence of meningococci on the nasal mucous membrane. It is not a symptom on which much reliance can be placed.
- Relapses* Recrudescences are common and may be numerous; but true relapses are rare, although they undoubtedly occur and may do so after a considerable interval of apparent recovery.

8.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Diagnosis is usually simple in epidemics but is more difficult in the sporadic cases. Characteristic features are the sudden onset with headache, vomiting, and pyrexia, rapid development of stiffness of the neck and head retraction, and symptoms of irritation of the meninges. In acute fulminating cases, the features are less marked but a haemorrhagic rash is usually present from the onset and may suggest the diagnosis. Brudzinski's neck sign is of great value and to a lesser extent so is Kernig's sign (see p. 44).

Special methods

The most important special diagnostic methods are: (a) Lumbar puncture and examination of the cerebrospinal fluid; the early lymphocytosis must be borne in mind. (b) Blood culture; a negative result does not exclude cerebrospinal fever. (c) Blood count; a polynuclear leucocytosis is almost invariably present except in fulminating cases. (d) Agglutination; the blood develops agglutinins to the meningococcus in the course of a few days, but the titre rarely rises above 1 in 100 and the test is of little value compared with examinations of the cerebrospinal fluid.

Difficulties in diagnosis may arise in differentiating certain other diseases in which the meninges are involved, and in interpreting individual symptoms which are also present in other conditions. *Differential diagnosis*

Of other causes of meningitis the most important are tuberculous, pneumococcal, and septic meningitis. In tuberculous meningitis the onset is slower, there is no head retraction, and the cerebrospinal fluid is characteristic. In septic meningitis a focus of infection can usually be recognized, and there is no tendency to head retraction either in this form or in pneumococcal meningitis. The diagnosis from epidemic encephalitis and from acute poliomyelitis is occasionally difficult. *From other types of meningitis*

Meningism or meningeal symptoms may be present temporarily at the onset of many pyrexial conditions such as pneumonia or typhoid fever. *From other fevers*

Haemorrhagic conditions, such as purpura, haemorrhagic smallpox, and haemorrhagic measles may cause mistakes. The rash is petechial in typhus but it does not appear before the fourth day, whereas it is an initial symptom in cerebrospinal fever. In subarachnoid haemorrhage the cerebrospinal fluid is characteristic. *From other haemorrhagic conditions*

9.—PROGNOSIS

The prognosis is bad in infants under two years and in adults over forty years of age, in the acute fulminating form, in forms with haemorrhagic eruptions, and in cases with pulmonary complications. A prognosis of complete recovery can never be given until convalescence is established. The condition of the cerebrospinal fluid is of comparatively little value in prognosis.

The duration is very variable. The majority of the deaths take place towards the end of the first week but many occur later. Convalescence may occupy many months. *Duration*

The mortality varies greatly in different epidemics. Before the use of serum the case-mortality was rarely under 50 per cent and was often as high as 80 per cent, but with efficient serum treatment it should not exceed 30 per cent in an epidemic. The effect of serum is illustrated by the recent epidemic in 1932 in the West Riding of Yorkshire. According to E. L. Sturdee and W. M. Scott there were 2,095 cases notified of which 1,199 proved fatal, giving a mortality of 57 per cent; but in 421 cases which received efficient treatment with serum, the mortality was 29 per cent, and in 153 in which the serum was given in the first three days the mortality was 25 per cent. Serum treatment is more effective against type I meningococcus than against type II. *Mortality*

10.—TREATMENT

Emaciation develops very rapidly and a nutritious diet is of importance. It is frequently necessary to feed through a nasal tube. Bed-sores form *General hygiene*

readily and the skin needs careful attention. The headache is rarely relieved except by morphine and in many cases this fails. The general management of the case is otherwise symptomatic.

*Lumbar
puncture*

Lumbar puncture should be performed immediately, for the purpose of diagnosis and for the introduction of serum. The withdrawal of fluid tends to relieve the headache and reduce intracranial pressure.

*Serum
treatment*

Serum treatment should never be omitted even in doubtful cases and should be commenced as soon as possible, as the mortality is greatly reduced by early injections. It is essential that the serum employed should contain antibodies to the infecting strain. Nearly 90 per cent of all cases are due to types I and II and it is customary to use sera against these two strains until the type has been ascertained. The sera should be stored at a temperature between 5° and 15° C.

Technique

To perform an intrathecal injection, lumbar puncture is performed and cerebrospinal fluid allowed to drip away. The removal of the fluid is an essential preliminary and the amount of serum injected must never exceed the quantity of fluid removed. The serum is warmed to body temperature and introduced by gravity, the barrel of a syringe being connected with the trocar by a rubber junction. The serum must not be forced into the thecal space.

The ordinary dosage is 30 to 40 c.c. for an adult and 20 to 30 c.c. for a child. The injections should be continued until the cerebrospinal fluid is clear and the temperature falls, and should not be continued after this. Usually they should be given twice daily for the first two days, and once daily for the next four days. This whole course should be repeated if recrudescences occur.

*Intravenous
injection*

Serum should be injected intravenously in cases of meningococcal septicaemia without meningitis. Intravenous injections may also be given at the onset of cases which are seen early, but they should not be used in other circumstances; 100 c.c. of serum is mixed with an equal volume of physiological saline for an injection and this may be repeated every eight hours, the total serum given by this route usually being from 400 to 600 c.c.

*Cisternal
puncture*

Cisternal puncture should be used for the withdrawal of cerebrospinal fluid and injection of serum in those cases in which there is evidence of blockage of the spinal subarachnoid space.

Prophylaxis

It is clear from what has been stated above that, when many persons are sleeping in the same room, free ventilation should be provided and there should be an interval of three feet between the beds.

*Examination
for carriers*

When a case has appeared among a group of persons, contacts should be examined by swabs of the nasopharynx for the presence of meningococci, and positive contacts must be isolated. Treatment of carriers is unsatisfactory. Inhalation of chloramine vapour should be given daily. The vapour should contain 1 to 2 per cent of chloramine and be inhaled for 15 to 20 minutes. The following aqueous spray, released from an atomizer into the nostrils and mouth, may be used:

Chloramine	-	-	-	-	- 1.0 gram
Soluble saccharin	-	-	-	-	- 1.0 gram
Sodium chloride	-	-	-	-	- 0.5 gram
Distilled water	-	-	-	-	to 100.0 c.c.

No good effects have followed vaccine treatment; and there are no data on which to decide if prophylactic inoculation has any value. *Prophylactic inoculation*

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CEREBROSPINAL FLUID

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Reference may also be made to the following titles:

CEREBROSPINAL FEVER
CONCUSSION AND COMPRESSION
MENINGITIS

224.] The general term cerebrospinal fluid describes the fluid which fills the ventricles of the brain, the large basal cisterns, and the subarachnoid space. The fluid obtained from these three situations differs slightly in composition, the differences depending mainly on the addition of small

quantities of protein to the ventricular fluid as it passes over the internal surface of the brain and down the spinal canal. It is therefore more correct to speak of ventricular, cisternal, and lumbar fluids, and from the point of view of laboratory diagnosis this distinction is essential.

1.—ANATOMY AND PHYSIOLOGY

There is little doubt at the present time that the cerebrospinal fluid is formed chiefly by the choroid plexuses in the ventricles of the brain. The chief of these lie in the body and descending horns of the lateral ventricles where they are supplied by the anterior choroidal artery. The attenuated end of each plexus passes through the foramen of Monro to the third ventricle and reaches the under surface of the splenium of the corpus callosum where it is fed by the posterior choroidal artery. Thus all the three arteries which supply the circle of Willis (internal carotids and basilar) contribute directly to the choroid plexuses. The venous drainage, however, passes almost entirely to the straight sinus, that from the lateral ventricles going via the choroid veins and the vein of Galen.

Choroid plexuses

Arterial supply

Venous drainage

The iter of Sylvius provides a channel whereby the fluid from the lateral and third ventricles passes to the fourth ventricle. Thence it escapes to the cisterna magna and cisternae pontis by the foramina of Magendie and Luschka. The former of these, an opening of variable size in the inferior medullary velum, has been denied existence by anatomists, but of its presence in the great majority of human brains there can be no doubt, and it is of considerable importance in radiological examinations of the ventricles of the brain. The foramina of Luschka, which are bounded by the inferior and middle cerebellar peduncles and the cerebellar flocculus, contain a process of the choroid plexus of the fourth ventricle, which protrudes as a small tuft into the subarachnoid space alongside the seventh and eighth cranial nerves. The cisterna magna lies between the inferior surface of the cerebellum and the lower part of the medulla and first cervical segment of the spinal cord, being bridged over by a layer of arachnoid which lies in contact with the dura mater covering the arch of the atlas and the posterior rim of the foramen magnum. It is about 2 cm. in depth, and rather more in vertical and transverse diameters. It communicates in a downward direction with the wide subarachnoid space surrounding the spinal cord, and in an upward direction with the lateral cisternae pontis. From the latter the fluid has access to the cisterna basalis which lies between the antero-superior surface of the pons and the optic chiasma, bounded laterally by the hippocampal gyri. This, the second largest cistern, is about 1 cm. in depth and 2 cm. in antero-posterior and lateral diameters. It contains most of the circle of Willis, the infundibulum and pituitary stalk, and the origin of the oculomotor nerves. The Sylvian fissures supply the chief means whereby cerebrospinal fluid passes from the cisterna basalis to the convexity of the brain. Although the anterior lips of the fissures are usually firmly applied

Iter of Sylvius

Foramen of Magendie

Foramina of Luschka

The cisterna magna

Cisterna basalis

Subarachnoid space

to one another, there is a tunnel, nearly 1 cm. in diameter, along the line of the middle cerebral arteries; this opens into the subarachnoid space over the convexity of the brain at the Sylvian point. Keith has shown that a wide shallow channel passes from this point to the vertex of the brain about 1 cm. behind the coronal suture. It is noteworthy that the mesial surfaces of the frontal lobes are usually in very close contact, the gyri of one lobe filling the sulci of the other, so that there is little chance for escape of cerebrospinal fluid in this direction. Keith has also shown that the inferior surfaces of the frontal and temporal lobes rest directly on the floor of the skull, the ridges on which mark the position of the sulci. The subarachnoid space in these situations is therefore little more than a potential space. These anatomical facts assume considerable importance in the consideration of meningeal infections. (The circulation of the cerebrospinal fluid is shown diagrammatically in Fig. 45, p. 357.)

Subarachnoid space

The subarachnoid space is usually defined as lying between the pia mater, which is intimately applied to the surface of the brain and spinal cord, and the arachnoid, which lies in contact with, although not adherent to, the inner surface of the dura mater. The space is traversed everywhere, except in the larger cisterns and channels, by fine connective-tissue trabeculae which unite the two membranes, and it is lined throughout by a delicate mesothelium. The outer surface of the arachnoid is covered by a robust layer of cells of peculiar character, to which del Rio Hortega has given the name arachnoidal exothelium. These cells probably contribute largely to the watertight nature of the space and explain the great difference in chemical nature between the subarachnoid and subdural fluids, the thin layer of fluid in the subdural space being very much richer in protein than the cerebrospinal fluid.

Spinal subarachnoid space

The spinal subarachnoid space is incompletely divided into an anterior and a posterior compartment by the ligamentum denticulatum. This division ceases at the level of the first lumbar vertebra where the spinal cord finishes in the conus terminalis, and from this level to its termination at the junction of the first and second sacral segments the subarachnoid space contains only the nerve roots of the cauda equina. Although the arachnoid ceases at this level, the dura mater is prolonged as a lining to the sacro-coccygeal canal. It is thus possible to make injections into the *subdural* space via this canal.

The subarachnoid space has prolongations along the roots of the cranial and spinal nerves as far as the ganglia. Those along the sheath of the oculomotor nerve, along the trigeminal nerve into the cavum Meckelii, and via the internal auditory meatus and the aqueduct of the cochlea into the internal ear, are of chief importance. The subarachnoid space also communicates with the perivascular (Virchow-Robin) spaces which surround the arteries and veins as they pass into the brain and spinal cord, and may receive cellular and chemical exudates from the nervous tissue along these channels.

Arachnoidal villi

Finally it is necessary to mention the arachnoidal villi. Those in the superior longitudinal sinus are known as Pacchionian granulations and

are visible to the naked eye, but microscopic structures of similar character are found in relation to most of the larger veins and venous sinuses of the brain and spinal cord. They are constituted by a core of loose connective tissue, continuous with the subarachnoid space, covered by a compact layer of exothelium. They probably constitute the chief means by which cerebrospinal fluid is absorbed into the venous system.

In the normal adult there are about 125 to 150 c.c. of cerebrospinal fluid, of which about half is contained within the ventricles of the brain and half in the subarachnoid space. As Magendie long ago pointed out, the amount of fluid increases with advancing age.

*Volume of
cerebrospinal
fluid*

(1)—Formation, Circulation, and Absorption

Modern work on the formation of the cerebrospinal fluid indicates that it is essentially a dialysate from the blood, and that it is formed chiefly by the physical forces of hydrostatic and osmotic pressure acting across the semipermeable membrane constituted by the walls of the choroidal capillaries. There is, however, some evidence that a biological factor, the secretory or at least selective activity of the cells of the choroid plexus, may play a minor part in determining the chemical constitution of the fluid. It has already been indicated that to the fluid formed by the choroid plexus there is an addition from the capillaries of the brain and spinal cord, and from the subpial capillaries. This normally adds protein and cells to the fluid, and in diseases of the nervous system may contribute many abnormal constituents. It is, indeed, to this process that most of the abnormalities found in the cerebrospinal fluid in chronic diseases of the brain and spinal cord are due. It is noteworthy that, under normal conditions, the addition of protein to the fluid from these sources increases with age. Thus in children the lumbar fluid differs much less from the ventricular fluid than it does in adult and senile persons. The stagnation of the fluid in the lumbar sac which results from prolonged rest in bed may also lead to a considerable increase in the protein of the lumbar fluid.

Formation

The question of the circulation of the cerebrospinal fluid has been much discussed and no definite conclusion has yet been reached. But there is strong evidence on clinical grounds that some formation and absorption of fluid is continually taking place. The controversy has chiefly centred round the circulation in the spinal canal. Observations in cases of spinal disease indicate that the fluid in the lumbar sac is renewed either continuously or intermittently, by admixture with the fluid from higher levels. It is probable that this is determined largely by bodily activity and alterations of posture, which act by increasing and diminishing the calibre of the veins within the cranium and spinal canal. The pulsations of the intracranial arteries which are transmitted along the spinal subarachnoid space may in a minor degree increase this interchange.

Circulation

The cerebrospinal fluid is absorbed chiefly into the veins and to a much less extent along lymphatic channels. Dandy's experiments, as well as

Absorption

observations on cases of hydrocephalus, prove that the chief site of absorption lies above the tentorium cerebelli, as obstruction of the subarachnoid space at the level of the mid-brain or basal cistern rapidly produces hydrocephalus. It is probable that the arachnoidal villi are the chief means of escape of cerebrospinal fluid into the blood-stream and that this escape is governed by physical forces similar to those regulating the formation of the fluid.

(2)—Normal Composition of the Cerebrospinal Fluid

Appearance	—	Clear, colourless watery solution.
Specific gravity	—	1·006 to 1·008.
Cells	—	0 to 3 per c.mm., chiefly lymphocytes with up to 10 per cent of medium-sized mononuclear cells.
Total protein	—	<i>Ventricular fluid.</i> 5 to 10 mgm. per 100 c.c. <i>Cisternal fluid.</i> 10 „ 25 mgm. „ „ <i>Lumbar fluid.</i> 15 „ 45 mgm. „ „
Globulin	—	<i>Nonne-Apelt reaction.</i> Negative (half saturation with ammonium sulphate gives a perfectly clear solution). <i>Pandy reaction.</i> Negative (1 drop of cerebrospinal fluid added to 1 c.c. of saturated phenol solution in water gives either a clear solution or a faint opalescence).
Chlorides (as NaCl)	725 to 750 mgm. per 100 c.c.	
Glucose	—	48 „ 58 mgm. „ „
Urea	—	10 „ 30 mgm. „ „
Phosphates		
(as inorganic P)	—	1·25 to 2·10 mgm. „ „
Sodium	—	300 to 350 mgm. „ „
Potassium	—	8 „ 12 mgm. „ „
Calcium	—	50 „ 70 mgm. „ „
Magnesium	—	3 „ 4 mgm. „ „
Cholesterol	—	Less than 5 mgm. „ „
Uric acid	—	0·3 to 1·3 mgm. „ „
Bicarbonates	—	21 mille equivalents per litre (Merritt and Fremont Smith).
Reaction	—	pH 7·25 to 7·42.

(3)—Pressure of the Cerebrospinal Fluid

The pressure of the cerebrospinal fluid in the horizontal position of the cerebrospinal axis is remarkably constant under normal conditions, varying from 100 to 150 mm. of water or cerebrospinal fluid. It is determined by the intracranial capillary and venous pressures, being usually slightly below the former and above the latter. It follows the more rapid alterations of intracranial venous pressure, rising with coughing and straining and in cases of cardiac back-pressure. Occasionally

abnormally low pressures, from 50 to 80 mm., are encountered; these usually occur in elderly or debilitated subjects, but their aetiology is not clear. In the vertical position of the body the intracranial pressure falls, usually below zero, while the pressure in the lumbar sac rises to a corresponding degree. In this position the level at which the fluid is at atmospheric pressure is usually about the level of the cisterna magna. It is important to remember that although the pressure of the fluid in the lumbar sac is a true index of the intracranial pressure with the patient in a horizontal position, this is not true for any other position of the patient. Nor can intracranial pressure be accurately judged at lumbar puncture by any computation from the height of the head above the lumbar canal.

2.—LUMBAR PUNCTURE

Lumbar puncture is usually performed with the patient lying on his side; the head is supported by a low pillow and both arms are kept in front of the body. The hands may clasp the back of the thighs above the knees or be placed on the opposite shoulders. The hips and knees are strongly flexed and the spinal column bent forward as much as is possible without discomfort. In this position a line drawn from one iliac crest to the other crosses the third lumbar spine. Lumbar puncture is made through the interspace immediately above or below this spine. The needle should be inserted in the mid-line rather nearer to the upper than the lower spinous process and directed straight forward in the mesial plane of the body. The interspinous ligament offers some resistance to the passage of the needle, but this ceases abruptly as the needle enters the subarachnoid space. The operation should be performed under strict aseptic precautions, and it is usually wise to inject a local anaesthetic under the skin at the point selected for puncture. Anaesthetization of deeper structures is unnecessary as the periosteum is the only sensitive structure below the skin and it is usually possible to avoid touching this. Anaesthetization of the skin, however, makes it easier for the patient to retain the desired position during the puncture. *Technique*

The most usual needle for manometric observations (see Fig. 1) is provided with a three-way stopcock and a stand-pipe glass manometer tube of 2 mm. bore. (An aneroid type of manometer is made in France which can be attached to the needle by thick-walled rubber tubing.) The manometer is attached to the needle when it has entered the spinal canal. The stylet is then withdrawn from the needle and as the first drop of fluid begins to escape the tap is turned so that the fluid runs into the manometer. The patient is then allowed to relax his position slightly and encouraged to breathe easily. The level to which the fluid rises in the manometer is noted as well as its movement with the arterial pulse and with respiration. It is advisable to watch this for a short time to make sure that a constant level has been reached. Free movement of fluid in *Manometric needles*

*Quecken-
stedt's
method*

the spinal canal (the absence of 'spinal block') is tested by compressing the jugular veins, first on one and then on both sides, a procedure which distends the intracranial veins and at once raises the intracranial pressure as shown by the manometric reading. On releasing the jugular compression the fluid should fall rapidly in the manometer to the original level. (This method of testing for spinal subarachnoid block was devised

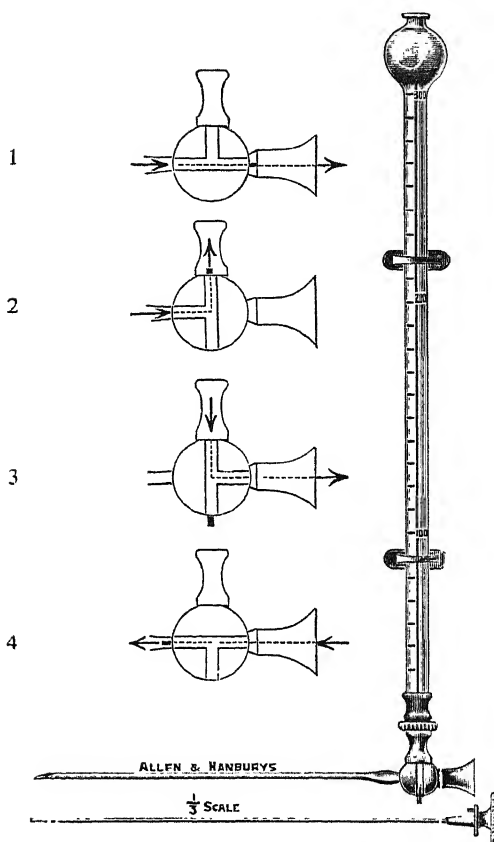


FIG. 1.—The author's lumbar-puncture needle for manometric observations. 1. Position for sterilization, and for insertion of the needle (manometer in communication with both ends of the needle). 2. Position for measuring manometric pressure. 3. Position for emptying manometer without drawing cerebrospinal fluid. 4. Position when used without manometer

by Queckenstedt, and is usually called by his name.) It is important, especially when manometric readings are desired, that the bevel of the needle should face up or down the spinal canal, since if it is directed laterally the opening may easily be blocked by a nerve-root.

3.—CISTERNAL PUNCTURE

Puncture of the cisterna magna has certain advantages over lumbar puncture, in particular that there is practically no risk of 'lumbar punc-

ture headache' even when the patient is allowed to follow his usual mode of life immediately after the puncture. It is also sometimes useful in assessing the degree of spinal block, and for the purpose of injecting lipiodol. Its only disadvantage is that it is attended with considerably more risk than lumbar puncture, as the medulla may easily be punctured if the needle is passed in too far. There is also a slight risk of haemorrhage from the posterior inferior cerebellar artery as it passes through the cistern on its way to the fourth ventricle.

Castex and Ontaneda elaborated a technique which they claimed to be free from the risk of puncturing the medulla. They find that the depth to which the needle has to be inserted to reach the cisterna magna can be

Choice between lumbar and cisternal puncture

Method of Castex and Ontaneda

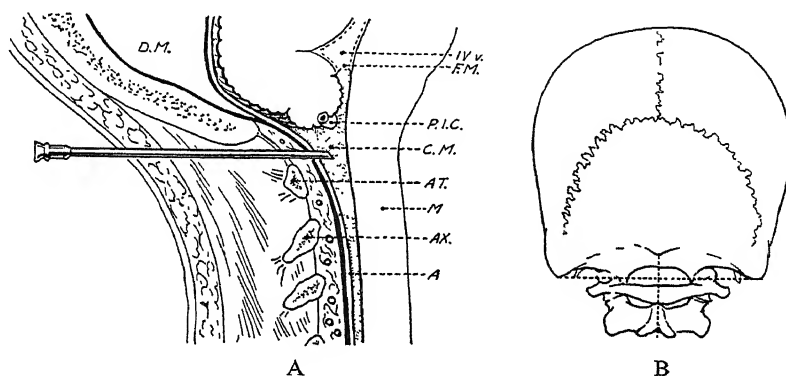


FIG. 2.—A. Drawing from mesial section of head and neck showing normal relation of structures surrounding cisterna magna. B. View of back of skull and arches of first two cervical vertebrae. The tips of the mastoid processes are on a level with the membrane joining the arch of the atlas and the posterior surface of the foramen magnum. IV.V. 4th ventricle. F.M. Foramen of Magendie. P.I.C. Posterior inferior cerebellar artery. C.M. Cisterna magna. AT. Atlas. M. Medulla oblongata. AX. Axis. A. Arachnoid. D.M. Dura mater of falx and venous sinuses. (After Castex and Ontaneda, *La ponction cisternale*.)

estimated exactly by measuring the antero-posterior distance from the back of the neck at the level of puncture to the anterior border of the tip of the mastoid process. This is measured on both sides of the neck by means of a small metal square, on one limb of which the distance from the other limb is marked in centimetres. The distance to the dura mater covering the posterior surface of the cisterna magna is calculated by subtracting from the reading (which should be the same on either side of the neck) 2 cm. in the male and 1.8 cm. in the female. The cistern puncture needle can be marked at this distance by passing it through a small rubber cork.

To perform the puncture the patient's head is bent directly forwards and the needle is inserted through the skin in the mid-line of the neck on a line joining the tips of the mastoid processes, and pushed forwards along the direction of this line, exactly in the mid-plane of the neck (see Fig. 2). It is advisable to withdraw the stylet when the needle has passed in almost to the estimated distance, and then to push the needle

very carefully forward, ceasing as soon as fluid begins to run from the needle. It should never be pushed on more than a quarter of an inch (0.5 cm.) beyond the estimated distance, which varies from 3 to 4 cm. in normal adults.

It is not so easy to obtain satisfactory manometric readings by cistern as by lumbar puncture. The muscles do not hold the needle in position and it must be carefully steadied by hand while the manometer is attached and the tap turned. It is unwise to attempt to do this without trained assistance.

Cistern puncture may be performed in the sitting position, but as the fluid pressure may then be negative, a syringe must be attached to the needle before it is pushed forward into the cistern.

4.—PATHOLOGY OF THE CEREBROSPINAL FLUID

(1)—Meningitis and Suppurative Infection of the Meninges

*Types of
meningitis*

The term meningitis includes all inflammations of the meninges, whether local or general, and whether involving the leptomeninges or the dura mater. The examination of the cerebrospinal fluid is of great value in assessing the cause and severity of the inflammation, and sometimes makes it possible to judge its extent, or at least whether it is localized or generalized. Any pathogenic micro-organism may cause meningitis, and some which are of such low virulence as to produce only mild degrees of inflammation elsewhere may produce severe and fatal disease when they affect the brain or meninges. Among these are pathogenic yeasts which occasionally cause meningitis, especially in wine-producing countries.

Infection of the meninges by pyogenic cocci may be secondary to infection of the cranial air-sinuses, the upper nasal passages (especially if there has been an injury to the cribriform plate of the ethmoid), or as a sequel of tonsillitis or acute infection elsewhere in the body. In the latter case the infection usually reaches the cerebrospinal fluid by the blood-stream, and probably via the choroid plexus. According to some, this is the route usually taken by the meningococcus, which can usually be found in the blood-stream during the earliest stages of the disease.

*Lepto-
meningitis*

The characteristic fluid in generalized leptomeningitis from pyogenic organisms is turbid and quickly forms a purulent coagulum. On centrifugalization the upper fluid is usually clear and colourless or slightly yellow. It contains an excess of protein, usually between 100 and 200 mgm. per 100 c.c. The chlorides are lowered to between 650 and 700 mgm. and glucose is usually absent. The other inorganic constituents show minor changes. Cholesterol is greatly increased to as much as 50 mgm. per 100 c.c. Complement is present. Examination of the deposit shows it to consist chiefly of polymorphonuclear cells with perhaps 5 per cent of mononuclears, chiefly of medium or large size. The pathogenic

organism is usually to be seen in the deposit, scanty and usually intra-cellular in the earliest stages and milder cases, but generalized in the fluid and often in large numbers in cases of greater severity. It can be readily grown on culture media. The presence of organisms in films of the deposit indicates a bad prognosis, and, except in infections by the meningococcus, *B. influenzae* (Pfeiffer), and some other organisms of low virulence, such cases usually prove fatal.

Infections of the meninges from suppurative conditions of the cranial air-sinuses are often at first localized. The examination of the cerebro-spinal fluid is of great value in such cases in assessing the extent and severity of the inflammation, although the problems which this examination presents are often of great difficulty. Inflammation of the dura mater, or septic thrombosis of the veins contained in it, often leads to symptoms suggesting meningitis. In such cases the fluid is usually clear and does not form a coagulum. Its pressure may be normal or slightly raised. Its protein content is not much increased and the percentages of chlorides and glucose are normal. The cell count may be normal, or there may be excess of cells up to 100 per c.mm. or more, a considerable proportion of these being polymorphonuclears. No organisms can be found in films or on culture. The higher the cell count the nearer is the inflammation to the subarachnoid space, and very high cell counts may indicate a local area of leptomeningitis. It is fortunate that the temporal lobes rest so firmly on the base of the skull in the region of the tegmen tympani that the subarachnoid space here is virtually obliterated. At least adhesions very rapidly form in this region and infection is therefore more likely to pass directly into the temporal lobe than to cause generalized meningitis. This unfortunately is not true of the posterior surface of the temporal bone, or of the region of the frontal or sphenoidal air-sinuses. But in these situations inflammation is often at first limited to the dura mater when it may produce an excess of cells in the cerebrospinal fluid with little other change.

*Localized
meningitis*

It is important to distinguish such fluids from those of the earlier stages of generalized meningitis. The formation of a coagulum, the rise in protein with the presence of complement, and the decrease in, or absence of, glucose are the most important features indicative of the latter condition. Culture will usually be positive when the infection is generalized, but occasionally micro-organisms may be grown from cases of localized meningitis. It is the rule, however, that so long as the meningitis is localized to the immediate neighbourhood of the dural inflammation, no organisms can be found either in films or on culture, and there is little alteration in the percentage of either glucose or chlorides.

*Generalized
meningitis*

Abscesses of the brain give rise to fluids which can only be distinguished from those of localized meningitis by their relatively greater protein content and higher pressure. The proximity of an abscess to the wall of the ventricles or to the surface of the brain, in a region where the subarachnoid space is comparatively wide, is signalized by

Brain absce

a rapid increase in the number of polymorphonuclear cells in the fluid. Very turbid fluids containing several thousand cells per c.mm., but showing little tendency to form coagula, are characteristic of this condition. The glucose is usually reduced or absent in such fluids, the chlorides retaining their normal level. But although such fluids are typical of cerebral abscess, it is not uncommon to find in chronic cases only a slight excess of cells, most or all of which are mononuclear, along with a moderate excess of protein. In rare cases the fluid may be normal.

*Tuberculous
meningitis*

Tuberculous meningitis produces fairly characteristic changes in the fluid. The pressure is raised, usually above 250 mm. The fluid is usually colourless or very faintly yellow, almost clear, but forming a fine cobweb coagulum after it is allowed to stand for some time. The cells are increased, usually to the neighbourhood of 100 per c.mm., the majority being lymphocytes in most cases. Polymorphonuclears are usually present and in acute cases, especially in childhood, may preponderate. A few plasma cells and other large mononuclear cells are usually seen. Tubercle bacilli are scanty but can be found in most cases by careful examination of the coagulum, or of the sediment after prolonged centrifugalization. The protein is raised in a variable manner, being usually below 100 mgm. in the earlier stages but rising as high as 300 or 400 mgm. towards the end of the disease. Complement is present from the beginning in considerable quantity. The percentage of glucose drops rapidly to between 10 and 30 mgm. but it does not usually disappear completely. The chlorides fall, usually below 650 mgm., and in children often below 600 mgm. per 100 c.c. This great fall in chlorides, with persistence of a trace of glucose, and the typical cobweb coagulum and cell count are so characteristic of the disease that it is often possible to make a diagnosis even when tubercle bacilli cannot be found.

*Meningo-
coccal
meningitis*

In the early stages of meningococcal meningitis the fluid is only slightly turbid, but forms a coagulum and is found to contain from 500 to 1,000 cells per c.mm., almost all of which are polymorphonuclears. The chlorides usually fall to about 650 mgm. and glucose disappears. The characteristic Gram-negative diplococcus can usually be found as an inclusion in a few of the leucocytes. After serum is given the fluid rapidly becomes more turbid and the cell count rises, but organisms disappear from the fluid, and in favourable cases can no longer be obtained on culture. Glucose now returns to the fluid and the chlorides rise gradually. During the later stages and in subacute cases, the cell count may be predominantly lymphocytic, and no cocci can be seen in the deposit. It is claimed that in such cases the ventricular fluid may still contain abundant cocci. Not infrequently, in more chronic cases, the lumbar fluid becomes shut off from the ventricular fluid by adhesions in the subarachnoid space. It then becomes clear, yellowish, and highly albuminous. In such cases the cisternal or ventricular fluid should be examined. The return of glucose to the fluid and its sterility on culture are favourable signs in meningococcal meningitis.

Certain other micro-organisms produce somewhat characteristic alterations in the cerebrospinal fluid. Infection by *B. influenzae* (Pfeiffer) is characterized by the presence of indol in the fluid. The anthrax bacillus produces a haemorrhagic meningitis which is readily distinguished from spontaneous subarachnoid haemorrhage by the high temperature, and the coagulum, high cell count, and abundant bacilli in the cerebrospinal fluid. Infection by the pathogenic cryptococci (oidium, saccharomyces, torula) produces in the later stages mucoid fluids in which the pathogenic organisms may outnumber the cells, which are predominantly lymphocytes.

*Other forms
of meningitis*

(2)—Syphilis

Lumbar and cisternal puncture have proved their value both in the diagnosis and prognosis of neurosyphilis. The cerebrospinal fluid often provides the only evidence of syphilitic involvement of the nervous system, and often also gives valuable indications as to the form which the nervous disease has taken.

It has been shown that in nearly half of all cases of syphilis the cerebrospinal fluid at some time during the first two years of the disease shows a temporary inflammatory reaction consisting of an excess of cells and of protein. This is usually only moderate in degree in symptomless cases, and may not be associated with positive Wassermann and colloidal reactions. But when symptoms of meningitis are present, changes of much greater intensity appear in the fluid which may be slightly turbid and may form a fine coagulum. The cell count in such cases is greatly raised, up to several hundred per c.mm., the cells being chiefly lymphocytes with a varying proportion of polymorphonuclear and large mononuclear forms; the Wassermann and colloidal reactions are also usually positive. All these reactions clear up rapidly under treatment, but in about 15 per cent of cases a certain excess of cells and of protein persists for months or years. In Ravaut's experience the persistence of these slight meningeal reactions up to the end of the third year foreshadows the later development of some form of neurosyphilis.

In the tertiary stages the cerebrospinal fluid is not altered unless the nervous system is involved. In meningo-vascular syphilitic disease of the brain and spinal cord, the changes in the cerebrospinal fluid reflect only the meningeal inflammation. These may vary in degree from very high cell counts, with considerable increases in protein and globulin and strong Wassermann and colloidal reactions, to mild or almost negligible increases in cells and protein with negative Wassermann and colloidal reactions. The cell count is always predominantly lymphocytic, but with counts above 100 per c.mm. some polymorphonuclear cells are usually present. When the blood-vessels alone are affected, as in syphilitic cerebral thrombosis, the fluid may be altogether normal. The intensity of the changes in the cerebrospinal fluid in such cases is no guide to prognosis, because the nervous lesions are due more to the vascular than to the meningeal disease. Thus some cases with severe in-

flammatory changes in the fluid clear up completely under treatment, whereas others in which vascular thrombosis plays a larger part are less benefited. Neither the type of colloidal reaction nor the strength of the Wassermann reaction during the early stages of the affection gives any indication as to the type of lesion present. But rapid disappearance of these reactions under treatment is of favourable omen.

*Syndrome
of Froin*

In chronic spinal meningitis of syphilitic origin, especially in cases of spinal pachymeningitis, there is usually some degree of spinal block. When this is complete the true syndrome of Froin may appear, namely, a yellow lumbar fluid, coagulating massively and containing excess of lymphocytes. This syndrome is rarely found in its entirety apart from syphilitic cases, although similar fluids, *but without lymphocytes*, are not uncommon in cases of spinal compression from tumours or vertebral disease. Modifications of the syndrome, such as colourless fluids with some degree of fibrinous coagulum, and considerable excess of protein and lymphocytes, are commonly found in cases of syphilitic paraplegia.

*General
paralysis*

The fluid in general paralysis is usually colourless, and without coagulum, but a fine coagulum which is flocculent rather than fibrinous and which breaks up fairly readily on shaking the fluid, is not uncommon. The cell count is often low, but may reach 100 per c.mm. or more. A rather characteristic type of large mononuclear cell with very large, oval, or reniform nucleus is almost always present in such cases and forms from 3 to 10 per cent of the total cell count. Plasma cells also are always present. The colloidal reactions are of the paretic type, i.e. the maximum precipitation occurs in the first or second dilution, whereas in other forms of neurosyphilis the maximum is not usually reached before the third or fourth dilution. The Wassermann and Kahn reactions are very strong, often almost as strong as those of the blood serum. The protein is increased often rather above 100 mgm. The globulin reactions are strong as compared with the total protein, since it has been shown that more than half of the total coagulable protein in the fluid of general paralytics may be globulin, whereas normally and in most forms of disease in which there is excess of protein, globulin only forms one-fifth or less of the total protein.

Under treatment the cell count often diminishes rapidly, and there may also be some reduction in the percentage of protein. But the Wassermann, Kahn, and colloidal reactions alter very slowly and are usually strongly positive for some months after a clinical cure. It is characteristic both of general paralysis and of tabes that the Wassermann reaction in the fluid changes as slowly as, or even more slowly than, that in the blood, except after malarial therapy.

*Tabes
dorsalis*

In tabes dorsalis the cell count may be high in the early stages but is more purely lymphocytic. A few plasma cells may be present, but the large mononuclear form characteristic of general paralysis is rarely seen. The protein remains at lower levels and rarely exceeds 100 mgm. The globulin reactions are usually positive but globulin forms a smaller fraction of the total protein than in general paralysis. The colloidal

reactions usually give curves in the 'luetic' zone with maximum precipitation in the third or fourth dilution. The Wassermann and Kahn reactions are strongly positive in the cerebrospinal fluid in most early cases, even when the blood gives negative reactions. Under treatment these reactions gradually disappear in the same order as in general paralysis. In long-standing cases it is not uncommon to find perfectly normal fluids, especially in cases with negative Wassermann and Kahn reactions in the blood.

In congenital syphilis the alterations in the cerebrospinal fluid are altogether comparable with those in acquired syphilis. The meningeal reaction is at least as common during the first year of life as in the secondary stage of acquired syphilis, and the characteristic changes of tabes and general paralysis appear in congenital cases of these diseases. The percentages of protein and globulin, however, tend to be lower and the colloidal and Wassermann reactions to be weaker in children than in adults. Slight changes of a syphilitic character are often found in the fluid of healthy children with positive Wassermann reactions in the blood, and may foreshadow later involvement of the nervous system. On the other hand, in idiocy and imbecility of syphilitic origin the cerebrospinal fluid is usually normal.

*Congenital
syphilis*

(3)—Encephalitis, Encephalomyelitis, Poliomyelitis

The non-suppurative infections of the nervous system to which the generic term of encephalomyelitis has been applied are characterized by changes in the cerebrospinal fluid which, while varying greatly in intensity, are of the same general type. The chief changes are an increase in cells and in protein, sometimes accompanied by the presence of fibrinogen as shown by the formation of a coagulum. This is never more than the fine 'cobweb' seen in tuberculous meningitis, and although very common in poliomyelitis is rare in the other diseases of this group. Among these must be included the condition to which the term benign lymphocytic meningitis has been given, and which has been shown, in some cases at least, to be a virus infection of the central nervous system. The pressure is often raised in these conditions, but does not usually exceed 300 mm. It is, however, frequently normal—an important diagnostic point when the symptoms suggest meningitis or cerebral tumour.

The cells are usually predominantly lymphocytic. In most epidemics of epidemic encephalitis and of post-infectious encephalitis polymorphonuclear cells have been absent or at least very scanty. But in the earlier stages of poliomyelitis a considerable proportion of polymorphonuclears is usually found. In post-vaccinal and other forms of post-infectious encephalitis a considerable number of the cells are usually medium-sized or even fairly large mononuclears, whereas in epidemic encephalitis and most other forms of encephalitis, as well as in herpes zoster, very few cells larger than lymphocytes are seen.

The different types of encephalomyelitis differ in the relation of cells to protein in the cerebrospinal fluid. In poliomyelitis during the pre-

Poliomyelitis

paralytic and early paralytic stages, the cell count is fairly high, whereas the protein is only slightly raised. The presence of a fibrin coagulum in such a fluid is very characteristic of the disease, although so far as these characters are concerned, the similarity to the fluid of tuberculous meningitis or of some stages of neurosyphilis may be very close. At a later stage of poliomyelitis the cells become progressively less numerous and predominantly or entirely mononuclear, while at the same time the protein rises and may remain as high as 200 mgm. for several weeks after the onset of paralysis.

*Epidemic
encephalitis*

In epidemic encephalitis it is the rule that the protein shows comparatively slight increase. A cell-protein dissociation is often very well marked in this disease, from 50 to 100 cells per c.mm. being sometimes associated with a total protein content of 50 mgm. or less. On the other hand the protein may rise to the neighbourhood of 100 mgm. The globulin reactions are usually weakly positive.

*Post-
infectious
encephalitis*

In post-infectious encephalitis on the other hand the excess of cells and of protein usually go hand in hand. The cells are not usually above 50 per c.mm., while the protein varies from 50 to 100 mgm. In a fatal case of encephalomyelitis following measles I found 490 cells, of which 25 per cent were polymorphonuclears, along with 200 mgm. of protein and a strong globulin reaction. Similar fluids have been described in the literature, but are unusual in this disease. In herpes zoster a pure lymphocytosis of varying degree is associated with slight excess of protein. In this disease the cell count often lies between 100 and 500 per c.mm. whereas the protein rarely exceeds 50 mgm. A cell-protein dissociation is therefore the rule.

*Herpes
zoster*

*Benign
lymphocytic
meningitis*

In benign lymphocytic meningitis also, fairly high cell counts are often found with only slight excess of protein. There is usually no fibrin coagulum in this condition. The meningo-encephalitis of mumps is associated with very definite abnormalities in the cerebrospinal fluid, and, according to some writers, a large proportion of cases of mumps, whether or not they present symptoms referable to the nervous system, show abnormal fluids. When meningeal symptoms are in evidence the cell count may rise to 2,500 per c.mm., but remains almost purely lymphocytic. The excess of protein in this condition also is comparatively low, although it may rise slightly above 100 mgm. when the cell count is high.

Mumps

In all these diseases the chlorides vary little from the normal, although in some febrile cases they may fall to 680 mgm. The glucose is either normal or increased to the neighbourhood of 100 mgm. The Lange (colloidal gold) and other colloidal reactions often give fairly strong curves in the middle zone. In a few cases of epidemic encephalitis curves of paretic type have been obtained, but these are exceptional.

(4)—Acute Febrile Diseases and Exanthemata

The cerebrospinal fluid is usually normal in the acute exanthemata except when there are nervous complications. Occasionally, however

a slight excess of cells is found in cases of measles or scarlatina which are following a normal course. Mumps and whooping-cough are more usually associated with abnormal fluids. The meningo-encephalitis of mumps has been discussed on page 66. In whooping-cough also an excess of lymphocytes in the fluid is not uncommon, and this may be accompanied by some rise in the percentage of protein. In typhoid fever the fluid is usually normal in cell count and protein content unless there is definite meningitis, but the chlorides are often lowered, sometimes to the neighbourhood of 600 mgm. From such apparently normal fluids *B. typhosus* may sometimes be cultured.

The occurrence of 'meningism' at the onset or during the course of febrile diseases in childhood is not very rare. In such cases the fluid is under an increased pressure, but the cell count is normal and the protein content low (10 to 15 mgm.). The only abnormality is a fall in the chlorides to 650 or 680 mgm. It is probable that the increase of pressure of the cerebrospinal fluid in these cases is often caused by the rapid hydration of the blood, with lowering of the serum chlorides, which may accompany a sudden rise of temperature or severe vomiting and diarrhoea if considerable quantities of water are drunk to allay thirst. Such cases are usually greatly benefited by lumbar puncture.

(5)—Tumours of the Brain

The examination of the cerebrospinal fluid is of great importance in the diagnosis of cerebral tumour, especially when papilloedema is absent. Lumbar puncture is almost always preferable to cistern puncture in such cases, and should be performed in the horizontal position. As the pressure of the cerebrospinal fluid affords the most important evidence of the presence of cerebral tumour, manometric observations should be carefully made in every case in which this diagnosis is suspected. It is also advisable to use a fine needle, and to remove only as much fluid as suffices for purposes of diagnosis. When the pressure is at all raised, withdrawal of fluid should only be allowed to reduce the pressure to about two-thirds of its original level. It has been shown that a rapid reduction of pressure by lumbar puncture may cause oedema of the brain, and it is probable that deaths following lumbar puncture in cases of cerebral tumour are often attributable to this.

In most cases of cerebral tumour in which signs of intracranial pressure such as headache and vomiting have made their appearance, the pressure of the fluid is raised above 200 mm. Occasionally, especially in elderly patients, the pressure may be found to be within normal limits, i.e. below 180 mm. This occurs in patients who have had recent severe bouts of vomiting, and also in those treated by purgation or magnesium sulphate enemas. In such cases the reduction of pressure is usually only temporary. In patients in whom the only symptoms have been those of a focal lesion of the brain, low pressures may also be found, especially after middle life. It is well known that a gradual reduction in the size of the brain takes place throughout adult life, and

there is therefore progressively more space which can be occupied by a tumour without leading to a pathological increase of intracranial pressure. Again when spontaneous decompression takes place by erosion of the base of the skull no increase of intracranial pressure may be found. It is a common observation that once the intracranial pressure has risen above 200 mm. it often continues to rise rather rapidly to dangerous levels of over 300 mm.

The fluid usually appears normal but a yellowish coloration or a fibrin coagulum may occur either singly or in combination. These appearances suggest a tumour either in the posterior fossa or close to the ventricles. Yellow coloration without excess of protein indicates recent haemorrhage in relation to the ventricles or subarachnoid space. This may have taken place either in the tumour or at a distance from it. For example, pontine haemorrhage is not uncommon in tumours of the cerebral hemispheres. The most typical fluid in cases of cerebral tumour is colourless with an excess of protein, but no corresponding increase of cells. Such a fluid, however, only occurs in a minority of cases. In about 50 per cent of the cases the fluid is normal, whereas in a small proportion of the remainder the cell count is definitely raised. As a general rule tumours of slow growth are less likely to give rise to abnormal fluids than those which grow more rapidly, but an exception to this rule must be made in the case of neurofibromas of the acoustic nerve which are constantly associated with an excess of protein, usually above 100 mgm. per 100 c.c.

Gliomas

Gliomas of the cerebral hemispheres may not produce any abnormality in the fluid if they lie in the more superficial parts, but all forms may cause a rise in protein when situated on the walls of the ventricles. Rapidly growing or degenerating gliomas in this situation may give rise also to a considerable excess of cells, among which polymorphonuclears often form a considerable proportion. Cell counts of 1,000 per c.mm. or over and of predominantly polymorphonuclear type are observed in some such cases and may lead to an erroneous diagnosis of cerebral abscess.

*Endo-
theliomas*

Meningeal endotheliomas are often associated with normal fluids, but an excess of protein may be found, especially if there is oedema of the underlying cerebral tissue or if the tumour lies near the basilar cistern. Endotheliomas in the posterior cranial fossa, or arising from the sphenoidal ridge or crista galli, also usually cause protein excess.

*Malignant
tumours*

Apart from the rapidly growing gliomas near the walls of the ventricles, the only forms of tumour which are likely to give rise to an excess of cells are metastatic carcinomas, especially those in the posterior fossa and in the walls of the ventricles, and cases of so-called 'meningeal sarcomatosis'. In such cases many of the cells may be recognizable as tumour cells. A considerable proportion of eosinophil cells has sometimes been found in cases of hydatid disease or cysticercosis of the brain. The other constituents of the fluid are usually little altered and their examination affords no help in the diagnosis of cerebral tumour.

The ventricular fluid is frequently examined in cases of cerebral tumour and often affords valuable information. As a general rule the fluid from the lateral ventricles is normal when the tumour is in the posterior fossa, even when the lumbar fluid contains a considerable excess of protein. On the other hand, when the tumour lies above the tentorium the ventricular fluid is usually altered in the same manner as the lumbar fluid, these changes being always greatest in the fluid from the ventricle on the same side as the tumour. Differences in colour, cell count, or percentage of protein between the fluids from the two lateral ventricles are therefore valuable indications as to the side (left or right) of the tumour.

*Ventricular
fluid*

(6)—Hydrocephalus

The lumbar fluid in hydrocephalus differs in relation to the freedom of communication between the ventricles and the lumbar theca. In the communicating type the fluid is under raised pressure, and apart from an unusually low quantity of protein (usually 10 to 15 mgm.) does not show any cellular or chemical abnormality. In non-communicating cases on the other hand the protein is raised, whereas the pressure may be normal.

Lumbar fluid

The fluid from the lateral ventricles is always normal except in cases in which the cause of the hydrocephalus is a tumour in the third ventricle.

*Ventricular
fluid*

The cisternal fluid is also normal in communicating cases. In cases of tumour of the third or fourth ventricle it may show a varying degree of increase of protein. In some of the latter cases, as well as in those in which the foramen of Magendie is closed by adhesions, it may be impossible to obtain fluid from the cisterna magna. Cisternal puncture is therefore usually contra-indicated in hydrocephalus, but in occasional post-meningitic cases in which there is some blockage of the spinal subarachnoid space, it may be of value both in treatment (if fluid can be obtained freely from this site) and in assessing the position of the obstruction to the circulation of the fluid.

*Cisternal
fluid*

(7)—Spinal Tumours

The researches of Nonne, Raven, Ayer, and others have established the importance of examination of the cerebrospinal fluid in the diagnosis of spinal tumour. In fact the diagnosis is usually based on lumbar puncture combined with radiographic examination of the spine. In such cases careful manometric examinations are essential. Ayer has suggested double puncture, i.e. puncture of the cisterna magna and lumbar theca, as a means of testing for restriction of the spinal subarachnoid space. This technique has considerable value, but a simpler and more usual method is to test for spinal subarachnoid block by the Queckenstedt method (see p. 58), using lumbar puncture alone. An absence of any significant rise in the lumbar manometer on jugular compression indicates a complete spinal block at a level above the lumbar needle. Sometimes, on deep jugular compression, a rise may occur which is not followed by the normal fall when the pressure is released. This 'ball valve' pheno-

*Manometric
test for
spinal block*

menon indicates an almost complete spinal block. (The name is misleading as the phenomenon occurs with fixed as well as with mobile tumours, and depends on the fact that a very considerable excess of pressure above the tumour is needed to force any fluid past it, but the pressure realized below the block is insufficient to cause return of fluid toward the cranium when the jugular compression is released.) Incomplete spinal block is indicated by delay in the rise and fall of pressure, or by incomplete return of the pressure in the lumbar manometer to its original level. The presence of a spinal compression may be confirmed by other examinations. Nonne showed in 1909 that the percentage of globulin in the lumbar fluid is almost always raised in such cases. When there is complete spinal block very high values of protein exceeding 1,000 mgm. per 100 c.c. are sometimes seen, and a rise to between 250 and 500 mgm. is usual. In incomplete spinal block a rise to 100 mgm. or over is significant. Yellow fluids are sometimes found with the more vascular as well as with the more rapidly growing types of tumour, and some degree of coagulation in the fluid may be observed, but massive coagulation of a yellow fluid (often erroneously called Froin's syndrome) is rare. Ayer has insisted on the disproportion between the quantities of protein in the cisternal and lumbar fluids in cases of spinal tumour; but he has also shown that the fluid above a spinal tumour may contain excess of protein, although always to a less degree than that below the block. Thus the cisternal fluid in cases of tumours at the cervical or thoracic levels may contain about 100 mgm. protein, and the lumbar fluid taken from above vascular tumours, such as neurofibromas of the cauda equina, may contain considerably larger amounts. Even non-vascular extra-dural tumours such as chondromas or herniations of the intervertebral discs between the lower lumbar vertebrae may produce significant increases of the protein in the fluid above them.

The cell count is usually low in cases of spinal compression even if this is due to an inflammatory granuloma in the epidural space. A few cells, up to 10 per c.mm., are not infrequently seen, but they are of little significance. In cases of meningeal sarcomatosis, or widespread meningeal tumour, on the other hand, there may be a considerable rise in the cell count. The rarity of coagula in fluids from cases of spinal tumour, even in those containing very high proportions of protein, is due to the paucity of cells and the consequent absence of fibrin ferment. Addition of a trace of fresh blood, or contamination with blood during the puncture, will produce coagulation in these fluids, since fibrinogen is almost always present in greater or less amount.

(8)—Other Subacute or Chronic Diseases of the Central Nervous System

Disseminated sclerosis Of the commoner subacute and chronic diseases of the central nervous system the only one which produces characteristic changes in the cerebrospinal fluid is disseminated sclerosis. In this condition there is often, during the more acute phases, some excess of lymphocytes and of pro-

*Other
changes
due to block*

tein, usually associated with positive globulin reactions and colloidal reactions of varying strength. A fairly strong curve of the 'paretic' type, associated with a relatively low cell count and slight rise in protein, is a very characteristic picture, but is by no means constant at any stage of the disease. More often the colloidal curve falls in the 'luetic' or middle zone, and sometimes it is quite negative. Positive colloidal reactions are almost always associated with an excess of cells and positive globulin reactions. It is rare to find any cells other than lymphocytes, and these are mostly of the small type. The Wassermann reaction in the heated (inactivated) fluid is always negative.

In cases of diffuse myelitis and neuromyelitis optica (Devic's disease) *Diffuse myelitis* much higher cell counts, up to 100 per c.mm. or more, are common. The protein is also raised to fairly high levels (100 mgm. or more) but the colloidal reactions are not always positive and are rarely of the paretic type.

In Friedreich's ataxy and the different forms of cerebellar ataxy *Ataxy* the cell count and protein are often raised during the progressive stages of the disease. Positive colloidal reactions, sometimes of the paretic type, may occur, so that the fluid may simulate that of disseminated sclerosis. In more chronic cases the fluid may be normal at all stages.

In syringomyelia it is not uncommon to find an excess of protein up *Syringo-myelia* to 200 mgm., which may be associated with a partial spinal subarachnoid block. The cell count is not raised and the colloidal reactions are usually negative.

In amyotrophic lateral sclerosis and in subacute combined degeneration the fluid is usually normal, any slight increases of protein that may be found being attributable to the age of the patient and his condition of inactivity rather than to the lesions in the spinal cord. *Other diseases of the spinal cord*

In cases of myelomalacia due to vascular occlusion the fluid is usually normal, or shows a slight or moderate excess of protein.

(9)—Peripheral Neuritis

In some cases of peripheral neuritis great variations from the normal are found in the cerebrospinal fluid; in others it remains normal. It is probable that these differences in the fluid are related to differences in aetiology and in the gravity or stage of the disease, but in the present state of our knowledge of the aetiology and pathogenesis of polyneuritis it is impossible to make any clear correlation in this respect. It is, however, clear that the greatest abnormalities in the fluid occur in the condition known as 'acute infective polyneuritis' and that when neuritis is due to an exogenous poison, such as lead or arsenic, the fluid is usually normal. The polyneuritis associated with chronic alcoholism does not fall altogether within the latter category, since it has recently been shown not to be due to the direct effect of alcohol on nervous tissues. Excluding those cases of acute polyneuritis with very abnormal fluids which have in the past been too often attributed to addiction to alcohol there is, in the majority of cases of alcoholic neuritis, little

abnormality in the fluid, although in some a variable excess of protein is found. In 'acute infective polyneuritis' the percentage of protein in the fluid is usually high, varying from 100 to 500 mgm. per 100 c.c. or even higher. There is often also some excess of cells which in rare cases may reach 100 per c.mm. These are usually lymphocytes and large mononuclears, but up to 10 per cent polymorphonuclear cells may be found. There is often also a coagulum which varies from a fine cobweb to massive coagulation of the fluid. A yellow coloration of the fluid is often seen. These changes persist for varying lengths of time. In some cases they are transitory, whereas in others they may remain for months. The cell count usually falls to normal fairly rapidly, but an excess of protein above 100 mgm. may still be found six months or more after the onset of the disease.

*Landry's
paralysis*

In cases of Landry's paralysis it is usual to find a normal fluid, but in some cases which are clinically similar the changes in the fluid associated with acute infective polyneuritis may be found. In diphtheritic neuritis there is usually a slight excess of protein which rarely rises as high as 100 mgm. per cent. The cell count is not increased.

*Diphtheritic
neuritis*

*Sciatica and
neuralgia*

In sciatica also some excess of protein may be found especially in severe and progressive cases. In brachial neuritis and trigeminal neuralgia the fluid remains normal.

(10)—Subdural or Subarachnoid Haemorrhage

*Subdural
haematoma*

In cases of traumatic subdural haematoma the cerebrospinal fluid is often slightly coloured during the first two or three weeks. Thereafter it is colourless but occasionally contains small shreds of fibrin. The pressure is usually raised to about 200 mm., but this is not constant. There is no excess of cells, but the protein may be increased to between 50 and 100 mgm. Apart from the slight yellow colour of the early stages there is therefore nothing characteristic in the changes in the fluid.

*Subarachnoid
haemorrhage*

In subarachnoid haemorrhage the fluid is from the first evenly mixed with blood, but usually does not form any coagulum. After about twenty-four hours the clear fluid above the corpuscles is coloured canary yellow, and this coloration deepens progressively during the first week. At the end of this time, if the haemorrhage has been severe, a red tinge, due to free haemoglobin, may be added to the yellow colour, but free haemoglobin is rarely, if ever, present at an earlier stage. The increases in cell count and protein during the first two or three days can be accounted for by the blood admixture, but thereafter there is a rise in both constituents which usually attains its maximum at the end of the first week. At this stage there may be several hundred cells of which many are polymorphonuclears, and a few large macrophages containing granules of blood pigment. Such high cell counts are, however, only seen when the haemorrhage has been severe. The protein rises often to between 100 and 200 mgm. There is never much alteration in the percentages of glucose and chlorides, although the former may rise or fall slightly.

It is a general rule that red blood-corpuscles, when shed into the sub-arachnoid space, do not survive more than a week, and therefore the presence of red cells in the fluid drawn off nine or ten days after the onset of symptoms indicates continued or recurrent haemorrhage. *Recurrent haemorrhage*

(11)—Diabetes, Uraemia, and Narcotic Poisoning

The abnormalities in the blood chemistry which occur in diabetes mellitus and uraemia produce corresponding alterations in the chemistry of the cerebrospinal fluid. In diabetes the sugar in the fluid rises to about 50 per cent or 60 per cent of its level in the blood. When acetone is present in the blood it is also readily found in the cerebrospinal fluid. In uraemia the relation between the chemistry of the blood and cerebrospinal fluid is more complicated. Urea is usually present in approximately the same percentage in the cerebrospinal fluid as in the blood, and in the absence of acidosis may constitute the only abnormality in the fluid. Occasionally there is a temporary rise in the cell count and more commonly in the percentages of protein and glucose. The chlorides usually remain at about the normal level, but in patients dying with severe acidosis they may rise at the end of the disease to 800 mgm. or higher. *Diabetes and uraemia*

In cases of narcotic poisoning by barbiturates there is sometimes a considerable excess of protein up to 100 mgm. or even higher. The drug passes into the cerebrospinal fluid and may be readily recovered from it if relatively large quantities of fluid are examined. *Narcotic poisoning*

In bromide poisoning the fluid does not show any abnormality except the presence of bromides and a compensatory reduction in chlorides. More than 100 mgm. per 100 c.c. of sodium bromide are sometimes found in severe cases of this kind. *Bromide poisoning*

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CEREBROSPINAL SYPHILIS

See NEUROSYPHILIS

CERVICAL GLANDS

See NECK: TUMOURS AND OTHER MORBID CONDITIONS; *and*
LYMPHATIC GLANDS DISEASES

CERVICAL RIB

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1.—DEFINITION

225.] The name cervical rib is given to an accessory and usually rudimentary rib attached to the seventh cervical vertebra, often bilateral, and found more commonly in women than in men. Its occurrence is associated no doubt with the peculiar development of this vertebra in that there is a separate ossific centre for the anterior or costal element of its transverse process, homologous with that part of a thoracic rib that lies proximal to the tubercle. Clinical interest lies less in the anatomical variation than in the peripheral nerve and vascular lesions that result, in all probability, in each case from the close proximity of the rib to the trunks of the brachial plexus.

2.—ANATOMICAL BASIS OF THE SYMPTOMS

(1)—The Rib

*Three grades
of develop-
ment*

*Fibro-
muscular
band*

Rib

*Rib with
joint*

In the degrees of development attained by cervical rib three grades are seen. The first and commonest grade is an enlargement of the costal element of the transverse process of the seventh cervical vertebra. The enlargement may be either small or considerable, and is usually prolonged in the form of a thin fibrous or fibro-muscular strand, passing from the transverse process to the upper surface of the first thoracic rib. This band, translucent to X-rays, is often responsible for the production of nervous effects; it may be present without enlargement of the transverse process, in which event there may then be nervous manifestations of the presence of cervical rib without radiographic signs. In its most characteristic form a transverse process equipped with such a band shows in a radiograph a sharp downward-hooked extremity, the point of which is the place of attachment of the fibrous band.

In the second grade there is a more fully formed rib reaching to the upper surface of the first rib but with no articulations other than bony continuity.

The third grade has a more or less well-formed joint at the junction of the transverse process with the cervical rib but the distal end is usually fused with the first thoracic rib, although a joint is sometimes seen here, and there may even be a costal cartilage joining the cervical rib to the sternum. The degree of anatomical development of the rib, however, has little relation to the intensity of the nervous symptoms produced, for the most severe paralysis may be associated with a thin band invisible radiologically. Indeed it appears that the effects on the brachial plexus, most typical of cervical rib, are produced by small ribs and bands; whereas the clinical picture presented by those of the well-grown ribs are often both slighter and less characteristic although sometimes more diffuse.

(2)—The Brachial Plexus

*Pre-fixed
plexus*

*Post-fixed
plexus*

The segmental derivation of the brachial plexus is not constant. In some cases it receives a considerable contribution from the fourth cervical root, a small one from the first thoracic, and none from the second thoracic root. Such a plexus is said to be pre-fixed. A post-fixed plexus, on the other hand, does not receive fibres from the fourth cervical root, but receives a large quota from the first thoracic root and fibres also from the second thoracic root. The development of the ribs is held to be modified by the presence of the segmental nerve trunks, and it is therefore thought, without certain knowledge, that the pre-fixed plexus is more likely to be associated with a supernumerary (seventh cervical) rib than the normal or the post-fixed, the last being indeed so placed in relation to the normal first thoracic rib that the nervous effects

usually referable to cervical rib may result from pressure of the first rib on the plexus.

There is not any general agreement regarding either the actual trunk or trunks compressed or the way in which the cervical rib produces its effects. This surprising uncertainty is due to the fact that the chief opportunity for anatomical observation is gained in operations for cervical rib, and in these procedures it is especially important that there should be the least possible manipulation and disturbance of the brachial plexus, only a small part of which is thus seen by the surgeon. Another reason for ambiguity is the difficulty experienced in forming a conception in three dimensions of the relations of the parts, especially when the constant use of skiagrams encourages thinking in terms of two-dimensional shadows; for example, the normal obliquity of the first rib as it slopes downwards and forwards does not appear in an antero-posterior skiagram, and is not easily shown in a lateral skiagram owing to the interposition of the shoulder between tube and plate. At operations on the cervical rib only a very small part of the first rib is seen by the surgeon, yet the normal obliquity of the first rib is probably of great consequence in the production of symptoms.

*Cause of
nerve
compression*

The cervical rib, if small, lies in the substance of the scalenus medius, the homologue in the neck of the intercostal muscles. Passing from the end of the rib is the band already described which, if muscular, is also homologous with the intercostals. In front of the scalenus medius is the scalenus anterior, and in the interval between them lie the emerging roots of the brachial plexus. In its upper part the interval is a slit, but it widens a little below as the first rib is approached, becoming a narrow triangle with an obliquely placed base formed by the downward and forward sloping first rib, so that the angle subtended between this and the scalenus medius is widely obtuse. The triangle accommodates the subclavian artery as well as the lower trunks of the plexus, of which the lowest is made up of the roots of the eighth cervical and first thoracic nerves, uniting as they lie on the first rib behind the subclavian artery. The first rib not only lies obliquely but its upper surface is concave, upwards and forwards, so that the posterior part may be almost vertical, as shown in the radiograph reproduced in Plate V, A in which the radiologist has succeeded in showing the first rib in a lateral view. The first rib, where the scalenus medius is attached, has therefore a direction so slightly inclined to that of the muscle as to lie almost parallel to it, while its inclination to the direction of the scalenus anterior is a slightly less obtuse angle.

*Anatomy and
homologies*

First rib

If we suppose that above, and therefore in front of, the posterior part of the first rib there lies a cervical rib with its continuing fibrous cord, it is clear that there must be partial obliteration of this narrow triangle from behind, and that the lower parts of the plexus must therefore be displaced forwards towards the scalenus anterior, the lowest trunk being thrust with the subclavian artery into the narrow acute angle between the proximal part of the first rib and this muscle. This is my inter-

*Displace-
ments caused
by cervical
rib*

pretation of what is seen at operations and it will be noted that, being almost identical with the findings of Adson, it leads to conclusions similar to his. It explains the undoubted success which follows the operative division of the scalenus anterior advocated by Adson, who stressed the significance of the tightness of the scalenus anterior and its consequent retraction after division, and argued that division of this muscle permits the subclavian artery and lowest cord of the plexus to slip down-

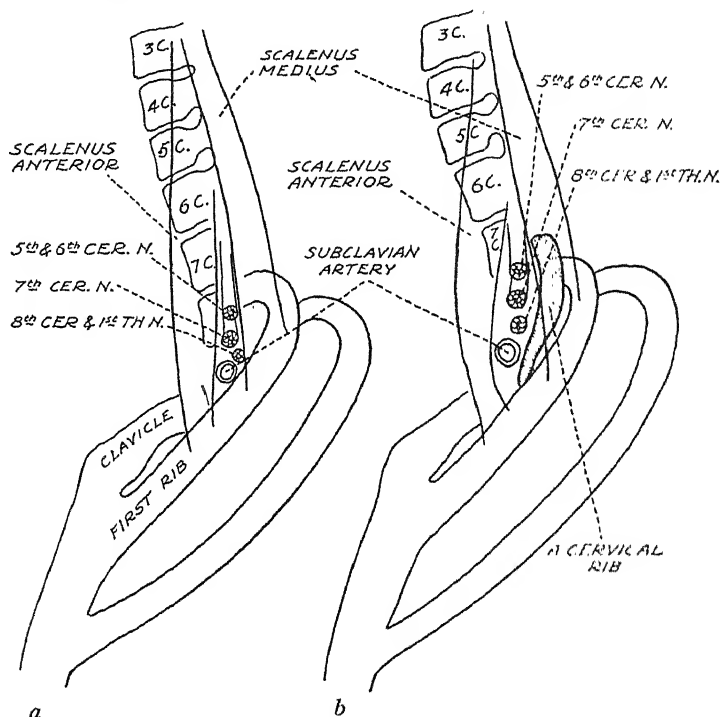
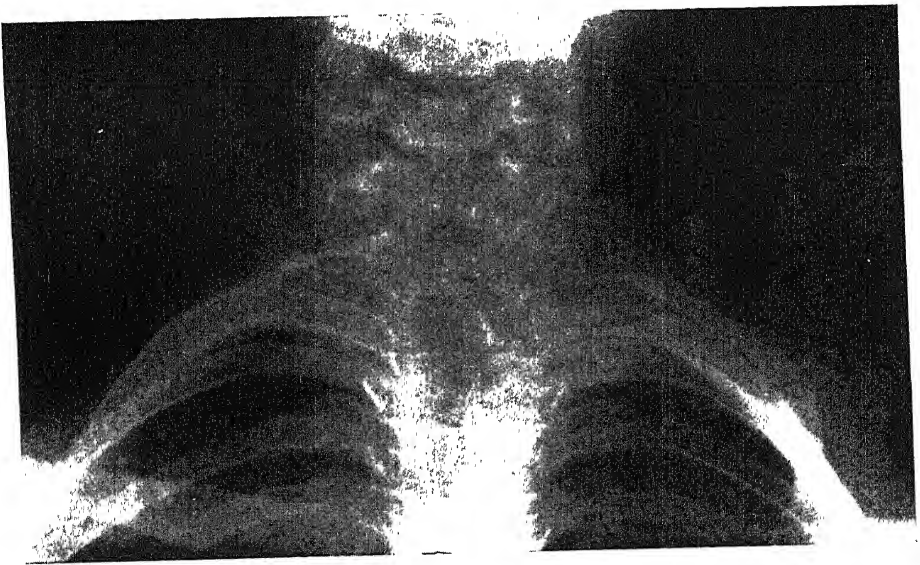


FIG. 3.—(a) A tracing of Plate V, A with the positions of the scalene muscles, the nerves of the brachial plexus, and the subclavian artery outlined. (b) A similar tracing of Plate V, A in which has been drawn an imaginary cervical rib. The scalenus anterior is shown displaced forwards and stretched, and in the narrow space between it and the cervical rib is seen the lower part of the brachial plexus, and the subclavian artery displaced forwards and upwards. The diagram shows not only how the united 8th cervical and 1st thoracic nerves and the subclavian artery are displaced, but also how the whole plexus may be affected

wards and forwards on the first rib, thus relaxing the tension of the plexus. I am of opinion that the removal of the anterior of the two agents compressing the plexus is of great importance in the relief of pressure, which may thus be effected without actual forward or downward movement of the nerve-roots.

*Compression
of roots*

The roots compressed are commonly the eighth cervical by the rib, and the first thoracic by the fibrous cord if this exists, or by the anterior part of the rib if it extends forwards. Remembering the steep descent of the whole plexus to the axilla, and the obliquity of the first thoracic and the cervical ribs, it is evident that the higher parts of the plexus may also be

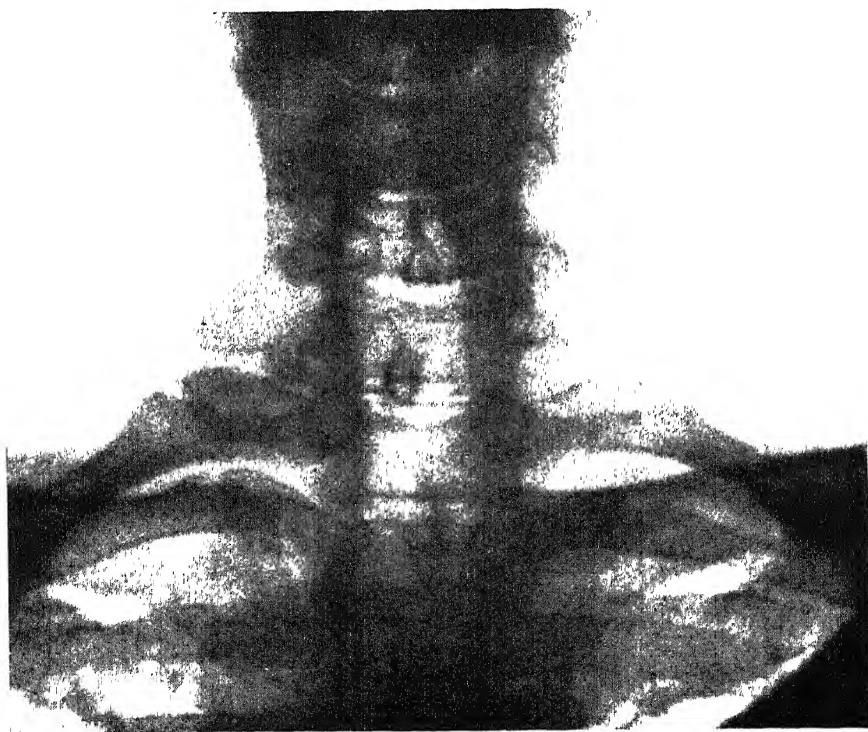
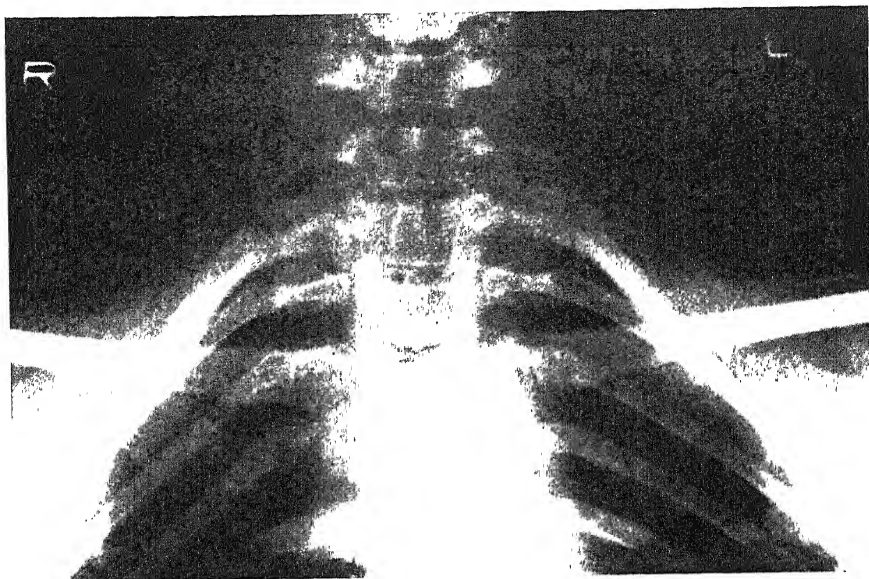


B

A. Lateral radiograph of thoracic opening showing normal obliquity of first thoracic rib. B. Bilateral cervical rib (patient in the care of Mr. A. J. Gardham). Radiographs by Dr. R. W. A. Salmond

PLATE V

[To face p. 78



B

A. Bilateral cervical rib. Photographs of patient's hands shown in Fig. 4. Radiograph by Dr. R. W. A. Salmond. B. Enlargement of transverse processes of seventh cervical vertebra. Radiograph by Drs. Coldwell and Allchin

PLATE VI

[To face p. 79

affected, and although there are rarely physical signs indicating affection of fibres arising higher than the seventh cervical, there is often pain in the arm and shoulder that suggests subjective symptoms emanating from fibres arising even as high as the fifth cervical.

(3)—The Subclavian Artery

In patients with cervical ribs it is often possible to feel the subclavian artery pulsating forcibly in the posterior triangle of the neck, and also to obliterate this pulsation as well as the radial pulse by downward traction of the arm. It was thought at one time that displacement of the subclavian artery might be the cause of vascular symptoms but, even if this is so, obstruction to the flow of blood cannot be the actual cause, for it is well known that it is possible to ligate the subclavian artery without visible effect on the hand or arm although the radial pulse may disappear. It is thought that the vascular effects are of the nature of spasm of the small vessels due to stimulation of their sympathetic supply by pressure from the cervical rib. The sympathetic nerve fibres to the upper limb probably pass in the first and second thoracic roots in which non-medullated axons have been demonstrated in large numbers by Stopford. Nevertheless there does seem to be some relation between unnatural pulsation of the subclavian artery in the neck and distal vascular effects, and although it is known that neither afferent nor efferent fibres pass to the peripheral vessels in the tissues immediately surrounding the main arteries, and thus that arterial displacement cannot produce the distal effects in question by affection of sympathetic nerves in the coats of the subclavian, it may be that the findings of Stopford, important as they are, do not provide the whole explanation of the vascular effects of cervical rib.

*Cause of
vascular
effects*

3.—EVIDENCES OF NERVE COMPRESSION

Evidences of nerve compression are of three kinds, sensory, motor, and vascular. Usually all three kinds of symptoms are present, but as a rule one predominates, and for descriptive purposes cases are grouped in terms of the predominant symptom.

(1)—Sensory Effects

Nearly all patients have some sensory symptoms, such as pain, tingling, or numbness, and they may suffer from all three. Many complain that the symptoms increase when the upper limb is in the hanging position and decrease when it is raised to shoulder level. The subjective sensory effects are mostly felt in the ulnar border of the hand, in the little and ring fingers, and sometimes also in the ulnar border of the forearm. But there are many atypical cases in which the symptoms are felt in the radial aspect of the hand and forearm or even as high as the deltoid area of the arm. When ulnar in distribution, the symptoms may be

Location

*Hypo-algesia
and hypo-
aesthesia*

accompanied by defective sensibility to touch and prick over a smaller area than that of the pain. The hypo-algesia and the hypo-aesthesia may proceed to complete analgesia and anaesthesia in any part of the affected area. Vague pains in the radial aspect of the limb without objective signs are apt to accompany massive long cervical ribs, whereas the ulnar effects with reduction of sensibility are usually seen with smaller, partly fibrous ones. It is thus common to find that when there are bilateral cervical ribs the smaller produces the more intense effects.

(2)—Motor Effects

Wasting

*Sequence of
events*

The motor effects consist of weakness and wasting of the small muscles of the hand and also, in severe examples, of the flexors of the wrist and fingers, showing in time the reaction of degeneration. Sometimes the whole hand wastes evenly, the thenar, interosseous, lumbrical, and hypothenar muscles becoming uniformly weak and atrophied. In other patients the process begins in a way characteristic of nerve compression by cervical rib and of no other form of muscular atrophy except that caused by a normal rib pressing on a post-fixed plexus. In this condition the weakness and wasting are seen first in the opponens and abductor brevis pollicis, the flexor brevis escaping at any rate for a long time. With total wasting of the thenar eminence the radial border of the first metacarpal bone becomes visible as a sharp ridge and the tissue of the first interosseous space becomes a thin membrane consisting of two layers of skin. When the flexor brevis pollicis is spared, the first interosseous space is of normal thickness and the rounded edge of the unaffected flexor is seen in sharp contrast with the hollow left by the wasting of the abductor and opponens muscles. This partial wasting of the thenar eminence, first described by Kinnier Wilson and well illustrated in the photograph reproduced in Fig. 4, gives a clinical picture easy to recognize and is diagnostic of the presence of a cervical rib. In time the wasting may spread to the other intrinsic muscles of the hand, but even when the whole thenar eminence and the interossei have wasted so as to leave visible the outlines of the metacarpal bones, it is still sometimes possible to feel a flicker of contraction in the flexor brevis pollicis in the distal part of the first interosseous space. I once operated upon a patient with such a paralysis of nine years' standing, in whom, after the operation, this observation was confirmed by the rapid return of power to the flexor brevis pollicis before any such recovery took place in the other small muscles. As with the sensory effects, paralysis in bilateral cases is commonly more intense on the side of the smaller rib.

(3)—Vascular Effects

Symptoms

Pain

The vascular effects are similar to those seen in mild cases of Raynaud's disease and are perhaps of like origin. They consist of coldness, cyanosis, and patchy pallor of the whole hand and to a less degree of the forearm. The hand is often painful, the pain being increased when the hand

is cold and when it is hanging down, and relieved when it is warm and when raised. The vascular effects sometimes proceed to patchy superficial gangrene of the extremities of the fingers. In one of my patients vascular effects were limited to the little and ring fingers without corresponding cutaneous sensory change and without muscular paralysis. These appearances were never explained and when exploration of the associated enlarged transverse process of the seventh cervical vertebra was carried out no compression of the brachial plexus could be seen. *Gangrene*

4.—INCIDENCE AND CLINICAL PICTURE

Women are affected more often than men, and, though it is a congenital variation, cervical rib manifests its presence in adolescent or adult life, often in the third decade. This delay in appearance of symptoms is due to the fact that pressure on the brachial plexus by the rib is not felt until the descent of the shoulders, which occurs with advancing age and which is seen especially in the female sex with adolescent increase of weight of the shoulders and breasts, has proceeded to such an extent as to stretch the plexus against the rib. It will be readily understood that the symptoms of cervical rib are commoner in those with long necks and sloping shoulders than in those of square build, this anatomical feature being well seen in the radiographs reproduced in Plates V and VI. There are also accessory factors that favour descent of the shoulder by producing muscular weakness: pregnancy, exhausting illness, and injury to the upper extremity are examples. Thus when a patient long bedridden resumes the erect posture, general muscular weakness leads to descent of the shoulder; and similarly after injury to the upper extremity, weakness of the muscles suspending the limb to the spinal column and skull favours the same anatomical alteration. In such cases, when a cervical rib exists, no age is exempt from its effects and symptoms have appeared for the first time in patients more than sixty years of age. *Sex and age incidence*

Cervical ribs are not often palpable, but when large and well formed they may be felt in the posterior triangle of the neck and may even produce visible swelling. In the writer's experience such ribs do not as a rule produce the nervous effects commonly considered to be typical of cervical rib. *Palpation*

Cervical ribs are well shown in radiographs and the various forms are easily seen. Plates V, B and VI, A and B show the three grades of anatomical development described earlier. Plate V, B shows bilateral cervical rib of the third grade, the left having an articulation at each extremity while that on the right has a joint only at the proximal end. In the patient to whom this refers the symptoms were limited to diffuse pain in the shoulder and arm and there was no clinical evidence of nerve compression. In Plate VI, A cervical ribs of the second grade are seen taking the form of laterally and downwardly extending prolongations of the transverse processes of *Radiographic signs*

the seventh cervical vertebra. Here the partial atrophy of the thenar eminence described by Kinnier Wilson was well shown on the left side and in lesser degree on the right. Plate VI, B shows the first grade, or slight enlargement of the transverse processes of the seventh cervical vertebra, but on the left side the distal extremity is like a downward-pointing hook. This appearance indicates with certainty the presence of a fibrous band passing to the first thoracic rib. There is also cervical spondylitis. The patient was a man of sixty-four who had for two years complained of pain and numbness in the ulnar side of the left hand with weakness and wasting of the small muscles. At operation there was found to be compression of the plexus by a fibrous band passing from the transverse process to the first thoracic rib. The band was removed with the distal half of the transverse process and the hand made a good recovery.

5.—DIFFERENTIAL DIAGNOSIS

With a clinical picture as clear as that of cervical rib, including the radiographic discovery of the anatomical condition, it might be thought

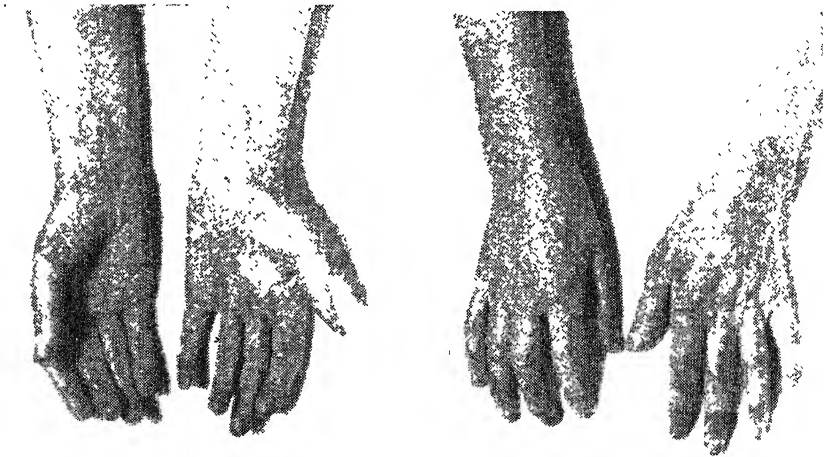


FIG. 4.—The palmar and dorsal aspects of the hands of a patient suffering from bilateral cervical rib. She moved her left thumb during the taking of the photograph but the wasting of the opponens and abductor brevis pollicis with preservation of the flexor brevis is well seen on the left side and to a lesser degree on the right side. The left hand exhibits also interosseous atrophy. The corresponding radiograph is seen in Plate VI, A. Patient in the care of Mr. Gwynne Williams

*Diagnosis
from nervous
disorders*

that there is little need for discussion of the differential diagnosis. There are, however, causes of difficulty of which the most important is the discovery of the existence of a cervical rib in a patient suffering from another organic nervous disease, which is itself the cause of defective sensibility or intrinsic paralysis in the hand. An adequate neurological

examination in all cases is the obvious way to avoid confusion and to recognize the presence of other maladies, such as peripheral neuritis, syringomyelia, and spinal tumour, all of which have been encountered by the writer in patients with symptomless cervical ribs. Other confusions, such as the question whether pain in an arm or hand without signs is due to nerve compression from a large transverse process, or whether in a patient suffering from peripheral neuritis associated with cervical spondylitis a co-existing cervical rib may be responsible for any of the symptoms, are harder to clarify. An exploratory operation may sometimes be justified. In general it may be said that the more the nervous manifestations are unlike the typical clinical picture, the less likely is operation to be of benefit.

From other conditions

6.—TREATMENT

When slight nervous effects have been precipitated by general muscular weakness following illness, or by local weakness after injury to the upper limb, it may be sufficient to prescribe exercises to restore the lost muscular power to the suspensory muscles of the shoulder; but in the majority of cases once the symptoms are manifest operation in addition is needed.

Exercises

(1)—The Operative Treatment of the Sensory and Motor Group of Cases

The aim of the operation is to remove that part of the cervical rib pressing on the brachial plexus, and the continuing band, if it is present, as far as the first rib, and also to divide the scalenus anterior muscle; the last, according to Adson, is all that is necessary (see p. 78). It is now universally agreed that, whether the rib is removed or not, division of the scalenus anterior should never be omitted.

Aim of surgery

The patient is put in position with the neck slightly extended over a small sandbag, with the shoulder tilted a little forward on another, and with the head rotated only a very little towards the opposite side. The adoption of this position relaxes the brachial plexus and permits of its exploration with minimal operative trauma. A horizontal incision is made across the posterior triangle, a vertical limb being neither necessary nor very helpful if the right level be chosen for the horizontal. It is easy to make the incision too near the clavicle, but remembering that the cricoid cartilage is at the level of the sixth cervical vertebra, that the origin of the cervical rib is against the seventh, and that this is the deepest and least accessible part of the operative field, a site should be chosen a little nearer to the plane of the cricoid cartilage than to that of the upper edge of the clavicle. The platysma, the external jugular vein, perhaps the lateral border of the sternomastoid, if this muscle is wide, and the omohyoid are all divided. The cellular and lymphatic tissues of the posterior triangle are incised in the vertical direction so as to expose the plexus with the scalenus anterior in front,

Technique

Site of incision

Dissection

the scalenus medius behind. Neither muscle needs further identification, but crossing the former from without inwards and downwards is the phrenic nerve, the integrity of which must be strictly respected throughout the operation; it should now be dissected free from its fascial bed. The superficial aspect of the brachial plexus is defined by most gentle dissection; this may entail the division of the transverse cervical vessels. The scalenus anterior is followed to its insertion on the first rib and the subclavian artery is seen lying behind it. The scalenus medius is then investigated, and in its substance towards the lower end is felt the bony prominence of the cervical rib. If a large rib is present, a bony mass extending forwards from the scalenus medius is encountered, but the following description concerns the more usual and more difficult case in which the rib is small and less obvious. The relation of the plexus to the rib and scalene muscles is now explored, a step that is facilitated by the position in which the patient has been placed, permitting slight traction to be made on the plexus without injury resulting. It will be seen that a part of the plexus which subsequent investigation will reveal as the eighth cervical root is displaced forwards on the bony rib, while below and in front the first thoracic root is similarly displaced by a tight fibrous band running downwards and forwards to the first rib behind and below the subclavian artery, almost to the scalene tubercle, where is inserted the scalenus anterior. Both roots may show sharply cut linear indentations at the sites of contact with the rib or band, clear evidence of compression. The actual exposure of these relations may be difficult because the scalenus anterior is always tightly stretched in front of the plexus, and structures behind it cannot yet be seen without unduly violent retraction of the nerve-trunks. This cause of embarrassment is removed immediately the scalenus anterior is divided, but before this step is taken the operator can observe the lower part of the plexus jammed with the subclavian artery into the narrow chink intervening between the rib and band behind and the scalenus anterior in front. The scalenus anterior is then divided piecemeal but completely, due care being taken of the phrenic nerve in front of it and the sympathetic cord to its medial side. As soon as it is divided the muscle withdraws from the field of operation and the relation of the plexus to the rib can be freely explored. Sir Percy Sargent often demonstrated that the fibrous band passing from the cervical rib to the first thoracic could be seen to become taut at every inspiration, thus fretting the root in contact with it. The removal of the rib and band may now be begun, the attachment of the band to the first rib being first detached. The remainder of that part of the bony rib that is causing compression may then be isolated and removed. There is no need to dissect as far as the vertebral body because the roots cross the rib far laterally to this, and because in dissecting the scalenus medius away from the more medial part of the rib the operator, provided he has a gentle hand with nerves, is now for the first time in danger of doing damage unwittingly. Here lies the one hidden danger of the operation, in the form of the branches passing

*Division of
scalenus
anterior*

through the substance of the scalenus medius from the sixth and seventh cervical roots to the nerve to the serratus anterior. They lie immediately behind the plexus and may be damaged near their origins unless deliberately sought and identified, but it is probably unnecessary to carry the removal of the cervical rib so far medially. Stress is laid by many surgeons on the removal of the periosteum with the rib in order to obviate, if possible, re-formation of bone. The work is completed by closure of the wound according to the individual method of the surgeon, the resulting scar being inconspicuous. It is usual for any forcible pulsation in the neck due to displacement of the subclavian artery to disappear with the removal of the rib. In all cases it is wise to institute exercises to develop the suspensory muscles of the shoulder after the wound has firmly healed.

Closure of wound

(2)—The Operative Treatment of the Vascular Group of Cases

Removal of the cervical rib has not always proved satisfactory in the vascular group of cases and when there are not any nervous effects other than the vascular changes it is probably best to perform sympathectomy without removal of the cervical rib. In the present article it would be out of place to discuss the varieties of sympathectomy, but my preference is for the recent modification of Telford by which, with section of the pre-ganglionic rami passing to the second and third thoracic ganglia and of the sympathetic trunk below the latter, the ocular effects of Horner's syndrome (miosis, ptosis, enophthalmos, and anidrosis caused by paralysis of the cervical sympathetic) may be avoided, a disfigurement that surgeons too often consider insignificant but that patients rarely hold to be trivial. According to Ross, sympathectomy has the same measure of success in these cases as in those of Raynaud's disease.

Sympathectomy

(3)—Results

The immediate post-operative results are encouraging and patients with bilateral symptoms usually press for removal of the second rib when they have experienced the relief consequent on removal of the first. Pain is often for the time completely abolished and when muscles have not suffered too serious atrophy, contractile power rapidly returns and the interosseous spaces fill out. Many patients go on to complete recovery but there are others in whom, after an auspicious beginning, the process of recovery becomes retarded or arrested, really useful power failing to return and perhaps pain also recurring. This may be due to scarring but has also been associated with inadequate removal of the rib and with re-formation of bone. Secondary operations have been done on many occasions, but they are difficult and the results are, for obvious reasons, not very good unless they take the form of sympathectomy for recurring or uncured vascular effects. It is usually said that cases of the motor group are the most satisfactory of all, that those of the sensory group are less so and apt to retain, to some degree, both objective and

Prognosis

Causes of failure

subjective evidence of nerve involvement after operation, and that those of the vascular group are the least satisfactory. The last statement in all probability has now to be revised in view of the application of sympathectomy to the treatment of these cases.

I wish to express my indebtedness to Messrs. A. J. Gardham and Gwynne Williams for permission to make reference to patients under their care, and to Dr. Salmond and Drs. Coldwell and Allchin for permission to reproduce their radiographs.

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CERVICITIS

See UTERUS DISEASES

CESTODES, INFESTATION BY

See TAPEWORMS

CEYLON SORE MOUTH

See SPRUE

CHAGAS' DISEASE

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Reference may also be made to the following titles:

ARTHROPODS AND DISEASE TRYPANOSOMIASIS

1.—DEFINITION

(*Synonym.*—South American trypanosomiasis)

226.] Chagas' disease is an infection due to a protozoal parasite, *Trypanosoma cruzi*, and disseminated by certain reduviid bugs belonging to the genera *Triatoma*, *Rhodnius*, and *Eratyrus*. It is characterized by an initial febrile disturbance which may be severe in young children, and possibly by later chronic manifestations. So far as is known, the disease is limited to South and Central America.

2.—PROTOZOOLOGY

*Trypano-
soma cruzi*

The causal organism, *Trypanosoma cruzi*, is found in the blood, usually in scanty numbers, during the febrile stage of the disease (see Fig. 5). It is a curved, stumpy organism, about 20μ in length. Some of the

individuals are relatively broad, while others are more slender. The nucleus is central and the blepharoplast is large and ovoid and situated near the posterior end; the undulating membrane is narrow, and the free flagellum is about a third of the length of the organism. Longitudinally dividing forms of *T. cruzi*, such as are found in the case of other trypanosome infections, do not occur in the blood, and multiplication takes place within the cells of nearly every organ of the body, especially in the heart and skeletal muscles. When a trypanosome invades a cell it loses its membrane and flagellum and assumes a leishmania form, about 4μ in diameter; this divides by simple fission, and as the result of repeated division intracellular cysts are formed containing large numbers of leishmania forms. When this has happened, each of the leishmania forms develops a flagellum and

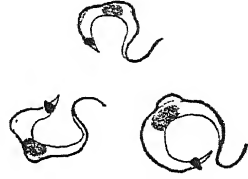


FIG. 5.—*Trypanosoma cruzi* from peripheral blood. $\times 1,300$

becomes again changed into a trypanosome which escapes into the blood after rupture of the parasitized cell.

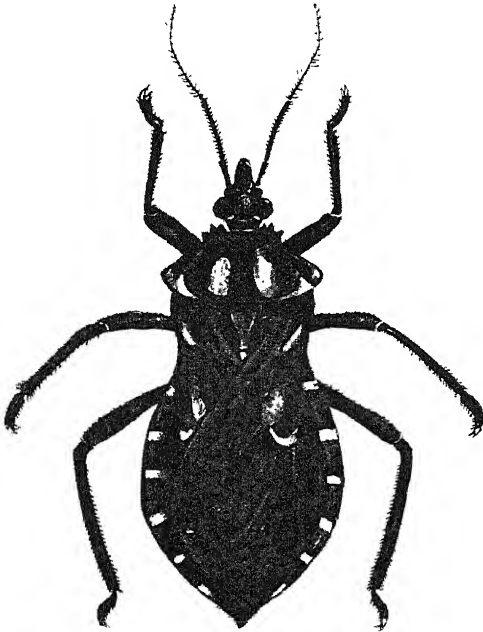


FIG. 6.—♀ *Triatoma megista*; dorsal view. (Patton and Evans, *Insects, Ticks, Mites and Venomous Animals of Medical and Veterinary Importance*, Part I, 1929; after Chagas.)

The infection is spread by *Vector* reduviid bugs. In Brazil the chief vector, *Triatoma megista* (see Fig. 6), is found in large numbers in the poorer houses, where they live in crevices in the mud and grass walls. The bugs usually attack the face and lips of the sleepers, and hence are called 'barbeires' or 'kissing bugs'. The trypanosomes, which are taken up by the bugs during their meal of blood, develop and multiply in the intestine of the insect. The developmental cycle is complete in from 6 to 15 days, and the infective forms (metacyclic trypanosomes) are discharged with the excreta.

The bugs defaecate when feeding or after a meal, and man becomes infected by contamination of the mucous membranes and skin with the excreta containing metacyclic trypanosomes. In endemic districts, according to Dias, the bugs are commonly found in the beds of the inhabitants, the bedding being

usually soiled with the excreta of the bugs and with blood-spots from crushed insects. Infection probably occurs most commonly by the droppings contaminating the mucous membranes of the mouth, nose, or eyes directly, or being introduced into the skin by scratchings.

3.—AETIOLOGY

Geographical distribution How far South American trypanosomiasis is a disease of grave significance must at the present be regarded as uncertain. Although the geographical distribution of infected bugs has not yet been fully investigated, there seems little doubt that they are widely distributed in the American continent between the latitudes 35° S. and 30° N. They have been found all over the south-eastern portions of Brazil and Uruguay, except in the coastal zone, in all the provinces in the northern portion of the Argentine, in Chile, Peru, Venezuela, Panama, Salvador, Guatemala, and as far north as the southern portions of California and Arizona, U.S.A.

In view of this wide distribution of infected vectors, surprisingly few human beings have hitherto been found to be actually infected with the trypanosome. The only district from which any considerable number of cases has been recorded is that of the State of Minas Geraes in Brazil, where Chagas first discovered the disease in 1909; and the only other State in Brazil in which definite instances of human infection have been found is that of São Paulo, from which four cases have so far been recorded.

Incidence Outside Brazil the total number of individuals in whom trypanosomes have been discovered is remarkably small; I have been able to find records of only 106 cases; these were scattered over an immense area. The total number hitherto found in the Argentine is 76, and these were distributed throughout all the provinces in the northern portion of the country, except Los Andes, Formosa, and Misiones. Two cases have been recorded from Peru, 4 from Venezuela, 19 from Panama, 2 from Salvador, and 3 from Guatemala. So far the trypanosome has not been found in human beings in Uruguay, Paraguay, Chile, or in Southern California, although infected bugs have been discovered in all these countries.

Notwithstanding the small number of cases in which trypanosomes have actually been found, it by no means follows that human infection is exceptional, or that the disease is of little pathological significance. Except during the initial febrile stage of the disease trypanosomes are rarely found in the peripheral blood; but it is possible that in the later stages of the infection the parasite continues to multiply in the internal organs and to produce lesions which cause various grave chronic conditions met with in large numbers in endemic areas in Brazil, Uruguay, and Argentina.

4.—MORBID ANATOMY

The pathological changes caused by the trypanosomes consist in degeneration of the invaded cells, and in a cellular infiltration of the affected tissue—resulting in a hyperplasia of connective tissue, and eventual fibrosis. In acute cases parasites have been discovered in almost every organ in the body, but the outstanding lesions have usually been in the myocardium, brain, and liver. Distribution
of parasites

The heart is usually enlarged, and there is an excess of pericardial fluid sometimes containing a few fibrinous flakes. Microscopic examina- Heart



FIG. 7.—Section of infected heart-muscle showing leishmania forms of *Trypanosoma cruzi*. $\times 1,300$

tion of the heart muscle shows the most pronounced changes (see Fig. 7); between the muscle fibres there is an intensive infiltration of lymphocytes, plasmacytes, macrophages, and round cells. The muscle fibres are widely separated from one another, and some of them show fragmentation and hyaline degeneration. Large nests of parasites can usually be seen in the muscle fibres or in the large mononuclear cells in the interstitial spaces. The epicardium and endocardium may also show in places cellular infiltration and nests of parasites. In cases which survive the acute stages, the infiltrated areas undergo fibrotic changes.

The lesions in the nervous system are those of a meningo-encephalitis. Nervous
system
The brain and meninges are congested, and scattered throughout the substance of the brain are focal lesions consisting of cellular infiltration, some of which contain nests of parasites.

The liver is enlarged and on section shows parenchymatous changes Liver
with extreme fatty degeneration. Parasites are rarely found in the liver, and the pathological changes are believed to be the result of toxins.

Spleen

The spleen is also usually somewhat enlarged, but the changes in this organ are often complicated by concomitant malaria.

Lymphatic glands

The lymphatic glands are enlarged, and histologically show congestion, lymphoid hyperplasia, and mononuclear cell production.

5.—CLINICAL PICTURE

The acute stage

Many of those in whose blood the trypanosome is found do not show any sign of disease and do not give a history of recent illness, beyond possibly a mild febrile disturbance with slight oedema and adenitis,

but there seems little doubt that in infants and young children the infection is associated with an acute febrile disturbance, which, however, varies considerably in severity in different cases. As a rule the younger the child the more severe are the symptoms.

In infants and young children the illness begins with a febrile disturbance, the temperature in severe cases rising to 104° F. A very common early sign is swelling of the eyelids and face. The oedema, which is sometimes accompanied by conjunctivitis, is firm, elastic, and painless, and may be so extreme that the eyes cannot be opened. It is often unilateral, and may probably be ascribed to the bite of the infected



FIG. 8.—Chagas' disease in a child of two, ten days after beginning of illness. Photograph by Dr. Salvador Mazza

bug. Experimentally it has been shown that man and animals can be infected by placing the excreta of infected bugs upon the conjunctiva, and it is believed that the face and eyelids or conjunctiva constitute the usual portals of entry of the trypanosome. The bugs bite the closed eyelids or the neighbouring regions of the face, and the child inoculates the wound or the conjunctiva by rubbing in the infected excreta.

The oedema may spread widely and involve the legs and arms. Associated with the oedema is an adenitis; the pre-auricular, sub-maxillary, and cervical glands are frequently involved, as are also the inguinal and axillary glands. There is progressive anaemia, and the pulse is frequent. The liver and spleen are enlarged, but the enlargement of the latter is probably often due in part to concomitant malaria. In severe cases various nervous symptoms such as irritability, con-

Onset

vulsions, twitchings, and clonic contractions have been described. As a rule, the cardiac signs in the acute stages are ill-defined, and indicated solely by the enfeeblement of the organ without the marked alterations of rhythm which are said to be characteristic of certain chronic cases.

The acute stage of the disease is of short duration. Among the severe *Prognosis* cases in very young children a considerable proportion of deaths have been recorded. Of the 29 acute cases seen by Chagas in Minas Geraes 11 proved fatal, and in the 7 cases recorded from Panama in patients under 3 years of age there were 3 deaths. In the patients who survive, the temperature usually returns to normal within a few weeks, and with the fall of temperature the trypanosomes disappear from the blood and the oedema and other signs subside. Sometimes, however, the febrile disturbance, with its accompanying signs, is prolonged for several months.

The chronic stage

Chagas believed that spontaneous cure does not occur, and that patients who survive the acute period all pass into the chronic stage of the disease, the manifestations of which are the result of multiplication of the parasite in the internal organs. He also held that the disease may from the first be a chronic infection without having passed through the acute phase. As already mentioned, in older children and adults the infection usually produces no immediate symptoms beyond possibly a mild febrile disturbance. Many of these infections were only discovered as the result of systematic examination of the blood of a large number of individuals, or accidentally during examination of the blood for malaria.

According to Chagas and his colleagues the chronic manifestations of the disease comprise cardiac forms; nervous forms with derangement of the intelligence, defects of speech, and paralyses; goitre, myxoedema, and hypothyroidism; and infantilism. If Chagas's views are correct, American trypanosomiasis is unquestionably of very great pathological significance. Later work, however, raised considerable doubt whether, in many of the conditions included by Chagas among the chronic forms of his disease, the trypanosomal infection was not simply superimposed on another disease. Kraus, Rosenbusch, and Maggio (1915 and 1916) were the first to impugn the validity of Chagas's views on the chronic forms of the disease, and the whole subject was again reviewed by Kraus ten years later. These authors point out that, excluding the chronic cardiac cases, the symptomatology of the chronic forms of the disease described by Chagas—goitre, derangement of the intelligence which may lead to idiocy, defects of speech, and aphasia, cerebral diplegia, cretinism, infantilism, and myxoedema—has a striking analogy with that of endemic goitre and cretinism in Europe. *Relation to endemic goitre*

The most recent work has, on the whole, tended to support the

contentions of Kraus, and the case against Chagas's view can now be summarized as follows:

1. It is impossible to distinguish clinically between the so-called chronic forms of Chagas' disease (the cardiac variety excepted) and the endemic goitre and cretinism of Europe.

2. Chagas's work was done in a hilly region of Brazil (Minas Geraes), where 75 per cent of the native inhabitants have goitre, and where a cretin, dwarf, or paralytic occurs in every family.

3. Infected bugs and infected human beings have since been found in many places where goitre and cretinism do not occur, namely, in certain provinces in the Argentine, in the Las Viñas region of Guatemala, and in Panama.

4. Notwithstanding all the experimental research which has been carried out with *Trypanosoma cruzi* no investigator has recorded any predilection on the part of the parasite for the thyroid gland, nor have they noticed hypertrophy of the gland as a result of their experiments.

Relation to
chronic
myocarditis

There still remains to be considered whether infection with *T. cruzi* results in a chronic myocarditis causing the so-called chronic cardiac form of Chagas' disease. The problem is one of the greatest importance, because of the large number of cases of chronic heart disease which have been recorded from various parts of South America. Chagas and Villela (1922) gave an account of no less than 62 such patients, between 11 and 54 years of age, who exhibited signs of tachycardia, bradycardia, alterations of conductivity, extrasystoles, auricular fibrillation, or complete arrhythmia. According to Gaminara (1923) the cardiac form of the disease is common in Uruguay. Scattered references to large numbers of individuals dying from syncope are found in the Argentine literature. Romaña (1934) drew particular attention to the large proportion of deaths from syncope in the northern portion of Santa Fé—in Florencia 5 of 40 deaths, and in Guillermina 20 of 228 deaths, were from syncope. In a later paper Romaña inquired whether 'there is any relationship between this infection and the scarcity of old people among our workers'. Similarly Mazza and Guerrini (1934) state that in Añatuya (Santiago del Estero), where they found 2 acute cases of Chagas' disease, no less than 22 of a total of 233 deaths were due to syncope.

While it is not yet possible to reach a definite conclusion on the relation of the trypanosomal infection to these cardiac manifestations, the following considerations seem to establish a *prima facie* case in favour of a chronic cardiac form of Chagas' disease:

1. Cases of chronic heart disease characterized by tachycardia or bradycardia, alteration of conductivity, extrasystoles, auricular fibrillation, and syncope are exceedingly common in many parts of South America, where infected bugs and cases of human infection with *Trypanosoma cruzi* are known to occur; and in certain districts syncope is responsible for a large percentage of the total deaths.

2. The parasite is known to have a predilection for the heart muscle,

and the commonest cause of death in the acute cases is parasitic myocarditis.

3. The pathological changes observed in the hearts of patients who have died from the so-called chronic cardiac form of the disease are said by Chagas, Crowell, Torres, and others to be characteristic. They apparently consist of an interstitial infiltration and fibrosis of the myocardium; occasionally parasites have actually been found in these lesions in chronic cardiac cases.

4. In a number of such cases trypanosomes have been found in the peripheral blood, and a large proportion apparently give a positive Machado reaction (see below). This, however, does not necessarily mean that the trypanosome infection is the cause of the heart condition any more than the finding of trypanosomes in cases of goitre and cretinism implies that they cause these conditions.

5. But if these cardiac lesions, so common in endemic regions, are not the result of the trypanosomal infection, it is not easy to assign a cause for them. They are apparently not found in endemic goitre and cretinism of Europe. Attention might be drawn to the syndrome described by Zondek (1918) as 'myxoedema heart', the main features of which are general enlargement of the heart, an indolent heart-action with slow pulse, and low or absent P and T waves in the electrocardiogram; these cases are curable by thyroid and unaffected by digitalis. It is possible that some of the cardiac cases ascribed to Chagas' disease may have been confounded with this condition, but the frequency and severity of the cardiac lesions in regions where Chagas' disease is endemic, and its occurrence in some places where endemic goitre is absent, suggest that the so-called chronic cardiac form of Chagas' disease can hardly be identical with myxoedema heart.

Possibly the cardiac condition may be due to syphilis, or the result of a secondary anaemia due to intestinal parasitism. Against the former hypothesis are the facts that the Wassermann reaction is usually negative and that antisyphilitic treatment is said to be useless; against the latter is the apparent absence of a similar state of affairs in other parts of the world where intestinal parasitism is equally common.

6.—DIAGNOSIS

In infants and young children fever, oedema particularly of the face and eyelids, adenitis, and enlargement of the liver and spleen should in endemic regions suggest the possibility of Chagas' disease. A definite diagnosis can, however, only be made by the discovery of the trypanosomes in the blood either by direct examination or by inoculation of the blood into experimental animals (preferably guinea-pigs). In the chronic stage of the disease, when trypanosomes are usually absent from the blood, the Machado reaction (a complement-

*Machado
complement-
fixation test*

fixation test in which the heart and spleen of a highly infected puppy are employed as antigen) is claimed by Villela and Bicalho (1923), La Corte (1927), Villela (1930), and Dias (1934), to be of the greatest value.

7.—TREATMENT

Prophylaxis Obviously prophylactic measures must be directed against the transmitting agent. These resolve themselves into the provision of better houses and the use of mosquito nets.

No drug is known to exert any action upon the infection.

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CHALICOSIS

See SILICOSIS

CHANCROID

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Reference may also be made to the following titles:

BALANITIS
LYMPHOGRANULOMA INGUINALE
SYPHILIS

1.—DEFINITION AND AETIOLOGY

227.] It is common in this country to diagnose as chancroid, or soft chancre, any non-syphilitic ulcer of the external genital organs of venereal origin, and also to attribute to chancroid any inguinal bubo that is non-syphilitic and has appeared to follow a venereal ulcer or abrasion.

On the other hand, it is usual to attribute chancroid to the streptobacillus of Ducrey. During recent years, however, much evidence has accumulated to show that by no means all lesions diagnosed as chancroid are due to Ducrey's bacillus and it is important to distinguish these types from what may be termed true chancroid.

Causal organisms

2.—CLINICAL PICTURE

The ulcerative lesions caused by infection with Ducrey's bacillus are usually found on some part of the skin of the external genital organs, or on the mucous membrane adjoining the skin surface, but in some patients, chiefly women, the peri-anal region is affected. Very exceptionally the ulcers may appear on other parts of the body. The incubation period is usually from one to three days, but in a small proportion

Distribution of lesions

Incubation period

Nature of lesions

of cases it may be a week or longer. The first lesion may be single or multiple and each usually appears as a small pustule which quickly breaks down to form an ulcer with an angry-looking areola; the individual lesion may remain quite small and regular in shape, as when a number of follicles are infected, but usually increases in size rather quickly and becomes an irregular ulcer with angry edges, more or less undercut. The base is cribriform and commonly covered with a slough or fragments of necrotic tissue. The surrounding tissues are not usually toughened though they may be oedematous, and the ulcer is generally more flexible than is a primary syphilitic chancre (see Plate VII). The sore is usually painful, sometimes exquisitely so. Although there may be only one chancroid on the affected parts, it is common to see a number of them and to find that they did not appear simultaneously. The appearance of sores in succession is of value in distinguishing chancroid from syphilitic chancres, which may be multiple but almost always appear simultaneously.

Complications

If chancroids occur under a tight prepuce this may become irretractile, or, the prepuce having been retracted, paraphimosis may result. In rare cases the tissues under the prepuce may become phagedenic with a very rapid necrosis of a large portion of the affected part. Bubo, however, is the commonest complication. The inguinal glands on one or both sides become painful and swollen, and usually suppurate. The course until the stage of suppuration and breaking of the abscess through the skin is usually rapid, a point which may help to distinguish the bubo of chancroidal origin from those due to other causes. In certain cases the bubo may be the only obvious lesion when the patient is first seen, and there may be no history of any sore, or at least any preceding lesion on the external genital organs may have been slight and transient. In a certain proportion of these cases of *bubo d'emblée* the micro-organism concerned is not Ducrey's bacillus but septic organisms absorbed through some trivial breach in the surface of the external genitals or, more important, the virus of lymphogranuloma inguinale.

Course and prognosis

The course of the disease may be very protracted, and the multitude of local remedies that have been suggested is evidence of its comparative intractability. As shown below, however, it usually responds to vaccine therapy.

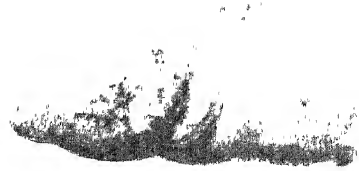
3.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Examination of secretion

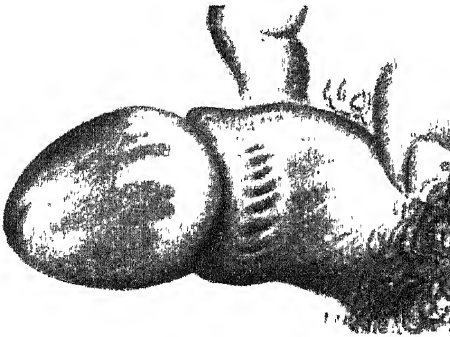
It should be axiomatic that in the case of every ulceration or abrasion of the external genital organs the secretion is examined for *T. pallidum*. Certain clinical characteristics have been mentioned as distinguishing chancroidal from syphilitic sores, but every one of them may on occasion prove misleading, and the exudation should always be examined microscopically. The simplest method of examination, if no microscope fitted with dark-ground condenser is at hand, is to allow the secretion which exudes after scraping the lesion to flow into a capillary tube



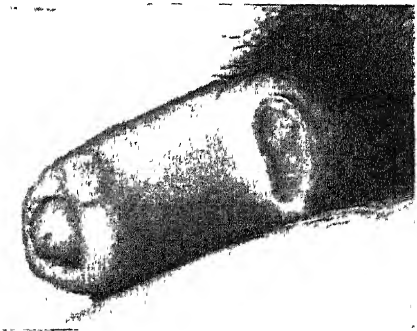
A.—'Fiddle-pattern' chancroid



B.—Multiple 'chancroids', probably due to infection of crop of herpes



C.—Simple balanitis. (From the Author's *Diagnosis and Treatment of Venereal Diseases in General Practice*)



D.—Chancroid with lymphangitis, and abscess at root of penis. (From *Medical Annual*, 1924)

PLATE VII

[To face p. 98

for transport to the laboratory. Until satisfactory specimens have been taken no antiseptic should be applied to the lesions. In the case of an ulcer which has the clinical appearance of a chancroid it may be useful to take a specimen of the secretion from under the edge and have it examined for Ducrey's bacillus. The secretion may also be examined for the Donovan bodies commonly found in granuloma venereum.

The blood should always be tested for syphilitic infection. A negative reaction does not, of course, exclude syphilis nor does a positive reaction necessarily indicate that the lesion in question is syphilitic, but for a number of reasons it is useful to know how the blood serum behaves in this respect. It may be that in the near future routine examination of the blood will include not only tests for syphilis but also complement-fixation tests for infection with both the gonococcus and the virus of lymphogranuloma inguinale. *Examination of blood*

With the proviso that specimens for laboratory tests are always taken, the following clinical features may help to distinguish chancroidal ulcers from others with which they may be confused. An incubation period of only a very few days, the absence of surrounding infiltration, comparative suppleness of the sore and, in the event of the sores being multiple, a history that they did not appear simultaneously suggests chancroid rather than a primary syphilitic chancre. An ulcerating gummatous syphilide is distinguished by its hardness, comparative painlessness, and response to the antisymphilitic remedies that would be given in the almost certain event of the blood giving positive reactions to the tests for syphilis. *Diagnosis from syphilis*

The presence of a number of minute ulcers each the size of a pin-head will suggest herpes rather than chancroid. *From herpes*

Gangrenous or erosive balanitis, sometimes called the fourth venereal disease, may be diagnosed as chancroid. It is usually more erosive than ulcerative, although numerous small ulcers may occur within the erosions. It is most widespread over the glans or inside the prepuce (which is long and tight) and, if at all severe, may lead to great swelling or even gangrene of the penis, and constitutional disturbance. The causative organisms are the spirilla and fusiform bacilli which occur in Vincent's angina, and these can be found in the secretion. If there is any suspicion that the condition is one of erosive balanitis rather than chancroid, the specific remedy for erosive balanitis, hydrogen peroxide, should always be freely applied (see Vol. II, p. 286). *From gangrenous balanitis*

Granuloma venereum, in places where it occurs only rarely, is commonly diagnosed as chancroid. It is important to make the correct diagnosis as soon as possible because granuloma venereum will defy all treatment for years until antimony is administered parenterally, after which it will usually heal in a few weeks. Meanwhile it may have spread widely over the genitals, the groins, and even the buttocks. Although found in most countries, granuloma venereum is much commoner in warm climates and among the black races. It usually progresses very much more slowly than chancroid; Nair and Pandalai describe it as taking *From granuloma venereum*

weeks or months to reach the size of a rupee. The growing edge and the base commonly show vegetations or granulations, which may break away leaving small punched-out ulcers. There is usually a thin watery or blood-stained, sticky discharge with a characteristic odour; in the discharge may be found the oval Donovan bodies, 'like gigantic bacilli with rounded ends', inside the mononuclear cells.

*From
squamous-
celled
carcinoma*

The diagnosis of squamous-celled carcinoma arises only when a sore has persisted for a long period and has become hard and infiltrated. In case of doubt a section should be examined.

*From lympho-
granuloma
inguinale*

Suppurative bubo is generally attributed at first to chancroid, and in most cases in which the course from the first swelling of the glands to their suppuration is rapid, this is correct. If, however, the progress is slow, the question of tuberculous disease, or of lymphogranuloma inguinale (L.i.) or climatic bubo should arise. In recent years it has been found that in cases of L.i. an intracutaneous injection of 0.1 to 0.2 c.c. of an antigen made from the pus extracted from an unburst bubo (Frei's antigen) produces a characteristic dome-shaped papule which persists for a number of days, sometimes necrosing in the centre. At the same time that Frei's test is carried out on the skin of one forearm it is usual to practise a corresponding skin test (Ito-Reenstierna test) for chancroid by injecting into the skin of the other forearm some killed culture of Ducrey's bacillus such as the commercial vaccine, dmelcos. A fallacy of these skin tests is that, if the patient has suffered in the past from L.i. or from chancroid, he will react to the corresponding antigen whatever the present condition.

4.—TREATMENT

*Vaccine
treatment*

Probably no pathological condition responds so well to vaccine treatment as chancroid. The most convenient vaccine is dmelcos, and a good initial dose for a man of average weight is 0.5 c.c., given intravenously. It is followed within a few hours by a rigor and a sharp rise in temperature sometimes even to 103° F., but as a rule the general reaction subsides by the following day. The second dose is usually given two days later and increased to 1.0 c.c. Thereafter the injections are repeated every second or third day, the doses being increased if the reaction following the preceding injection has not been unduly severe.

*Local
treatment*

The methods of local treatment that have been recommended are very numerous, and only a few can be mentioned, as follows: (1) Painting first with a 1 in 3 solution of zinc chloride followed by daily dressing with iodoform, 1 part, in vaseline, 3 parts. (2) Soaking in eusol or in chloramine solution followed by wet dressings of the same. (3) Spraying with hydrogen peroxide or with eusol followed by application of a 1 per cent ointment of mercurochrome-220. (4) Application on thin films of cotton-wool of a lotion made by mixing calomel 15 grams with lime water 120 c.c., shaking frequently during three days

and then adding camphorated tincture of opium 30 c.c. and zinc sulphate 30 grams. An important principle in treating chancroid is to maintain drainage. In my experience drying powders have been apt to cause bubo.

For suppurative bubo rest in bed is essential. If treated early the abscess may subside, but generally it has to be evacuated. This is best done by aspiration with a needle and syringe through the upper and outer end of the swelling. After evacuation colloidal silver, 1 in 2,000, can be injected and the surplus aspirated, after which the puncture opening is sealed and a pad applied. The aspiration may have to be repeated a few times as the abscess refills.

*Treatment
of suppurative
bubo*

If when first seen the skin is so thin that bursting is imminent, it is best to make a small opening about 5 mm. long at right angles to the line of the groin at the inner end of the swelling and then to insert a small wick of gauze. H. N. Cole recommends making a slight incision of 1 cm. long in the base of the bubo, expressing the pus, applying a pad and bandage for 24 hours, and then injecting, by inserting the nozzle of a record syringe, 1 or 2 c.c. of Menci re's solution (iodoform, guaiacol, eucalyptol, and 95 per cent alcohol of each 10; balsam of Peru 30, and ether 100). After this a pad is applied for 48 hours before the injection is repeated.

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CHARCOT'S JOINT

See JOINTS: DISEASES AND DISORDERS

CHEIROPOMPHOLYX

See DYSIDROSIS; *and* PEMPHIGUS

CHELOID

See KELOID; *and* SCLERODERMIA

CHICKEN-POX

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Reference may also be made to the following titles:

HERPES

SMALLPOX

1.—DEFINITION

(*Synonyms*.—Varicella; glass-pock; water-pox)

228.] Chicken-pox is an acute infectious disease, with or without prodromal features, characterized by an eruption of centripetal distribution, which tends to appear in successive crops, each lesion passing rapidly through a maculopapular stage to one of vesiculation and mild pustulation. The pustules then desiccate and scab, leaving little or no cicatrix.

2.—AETIOLOGY

The disease is highly infectious in the early stages and universally prevalent, being somewhat commoner in temperate climates than in the tropics. It is endemic in large centres of population all over the

*Geographical
distribution*

world; usually sporadic, outbreaks occasionally reach epidemic proportions and affect a wide area. Localized outbreaks in closed or semi-closed communities, such as schools, children's hospitals, and similar institutions, are frequent, and commonly involve the entire susceptible population unless prompt isolation measures are applied. It is mainly a disease of childhood, being uncommon after the age of ten years and relatively infrequent in infancy.

*Seasonal and
environmental
influences*

Alterations in the environment and distribution of susceptible subjects are probably of more importance in determining the magnitude of an outbreak than seasonal influences or biological variations in the infectivity of the causal organism. The disease is therefore most prevalent in the late autumn and winter, when those susceptible tend to be aggregated in groups for variable periods of time. In the absence of general compulsory notification it is difficult to obtain reliable figures of the incidence of the disease, but the data for the borough of Paddington for the years 1923 to 1929, when notification was in force, are instructive. It was shown that the disease was most prevalent in June or July of each year and, with the exception of 1929, a second peak was observed in October or November. During these years a small summer peak was usually followed by a large autumn peak.

*Age
incidence*

Intra-uterine development of chicken-pox is rare but undoubted cases have been recorded, as well as in the first few weeks of extra-uterine life. In infancy the disease, although infrequent, is by no means rare. The relative immunity enjoyed by infants is due in part to their sheltered existence, but is derived mainly from immune substances in the placental blood and milk of the mother. Susceptibility appears to be at its maximum between the ages of two and five years. From the seventh to the tenth year the disease is progressively less frequent and is uncommon after school age, but even adults are by no means free from risk of attack. One attack usually protects for life. Undoubted cases of second attacks have been observed, but they are very rare. The sexes are equally affected.

*Mode of
infection*

The disease is disseminated by droplets from the nasal and nasopharyngeal mucous membranes of infected subjects when speaking, coughing, and possibly during quiet respiration; also by means of the hands and clothing of attendants, or infected articles. In the early stages of the disease aerial convection of the contagion is possible over distances of 12 to 15 feet, and probably further. Although the virus does not appear to live long outside the body, a very small mass of infectious matter, provided it is fresh, apparently suffices for transmission of chicken-pox. Entrance into the host appears to be gained via the nasopharyngeal mucosa; little is known of the subsequent changes in the organism except that it is readily demonstrable in the fluid of recent vesicles. It is doubtful if healthy individuals ever act as carriers of the virus.

*Causative
organism*

Until comparatively recent years the causal agent of chicken-pox was unknown, although it was generally assumed to be a filterable virus. The work of Amies (1934) makes it appear probable that the 'elementary

bodies' originally described by Aragão in 1911, and independently by Paschen in 1919, are the actual infecting agents. These bodies are constantly present in the clear or slightly turbid fluid of early vesicles. Like the 'elementary bodies' of variola, they are rounded or ovoid bodies, approximately 0.125 to 0.175μ in diameter, take the Giemsa stain well, and are clearly visible under an oil-immersion lens. Suspensions of these bodies in physiological saline, specially purified by high-speed centrifugalization, are agglutinated by high dilutions of the homologous sera from patients recovering from chicken-pox, but they are not affected by sera from smallpox convalescents. The elementary bodies found in smallpox are likewise agglutinated by their homologous sera but not by varicella sera. The reaction may be used in the differential diagnosis of difficult cases.

Inoculation of chicken-pox by rubbing the contents of vesicles into scarified cutaneous surfaces has been successfully carried out, but the proportion of successful inoculations is much lower than with smallpox material. Circumscribed papules and vesicles usually appear in a few days at the site of inoculation but occasionally a generalized eruption results. The procedure appears to confer immunity. On the other hand, the application of the vesicle fluid to the unbroken skin or mucous membrane has failed to produce either local lesions or immunity.

3.—PATHOLOGY

There are not any essential anatomical differences between the lesions of chicken-pox and smallpox; in the latter they are larger, more numerous, and less superficial, but both are situated in the epidermis although at slightly different levels. The histological changes consist of dilatation of the capillaries in the papillary layer followed by exudation of serum. Liquefaction of the enclosed cells takes place, leaving the fully developed vesicle full of limpid fluid. Within a few hours opalescence appears, due to the entrance of cellular elements, chiefly mononuclears at first, although polynuclear cells later predominate. The corpuscles of Guarnieri, characteristic of smallpox, are never found in varicella fluid. The multilocular pattern of the smallpox vesicle, due to the persistence of capillaries and connective tissue elements, is absent in the more superficial lesions of chicken-pox. *Morbid anatomy*

There are not any characteristic changes in the blood during the incubation period. In the eruptive phase lymphocytosis, with diminution of eosinophils, lasting for a few days, is the rule. The other leucocytes are unaffected. *Blood changes*

4.—CLINICAL PICTURE

The great majority of attacks occur on the fourteenth or fifteenth day after the first exposure to infection. The interval is rarely less than twelve or longer than nineteen days, but authentic examples of periods as *Incubation period*

short as ten days and as long as twenty-three days have been recorded. The disease is contagious twelve to twenty-four hours before the appearance of the rash. Allowance must therefore be made for this time-interval when determining the duration of the incubation period. Moreover, great care must be taken to exclude the possibility of missed cases, or infection by fomites or other extraneous sources, particularly when the incubation period is prolonged.

When chicken-pox follows herpes zoster the incubation period is usually ten to sixteen days, but extreme limits of seven to twenty-four days have been recorded.

Symptoms in children

Prodromes are usually absent in young children. Exceptionally vomiting and convulsions occur, but most commonly the first hint of the disease is the presence of two or three maculopapules on the trunk, the earliest lesion perhaps already becoming vesicular. In some cases there is slight pyrexia, fretfulness, and disinclination for food for a few hours before the eruption appears. Older children usually show definite prodromal symptoms, such as headache, malaise, vague pains in the back and limbs, anorexia, and occasionally vomiting. There may be mild sore throat and a furred tongue, a slightly raised temperature, about 100° F., and accelerated pulse-rate. These symptoms rarely persist for more than a day and sometimes for a few hours only. In adults and adolescents the constitutional symptoms may be severe with fever, suggesting smallpox, but the relatively short duration, twenty-four to forty-eight hours, is an important distinguishing feature.

Symptoms in adults

Rashes

During the prodromal period various rashes may appear; in order of frequency they may be scarlatiniform, urticarial, or morbilliform. The first is by far the commonest, and is frequently confused with the rash of scarlet fever. In its typical form it is a simple non-punctate erythema, uniform or patchy, involving only the trunk. Occasionally it spreads to the extremities, particularly the inner surfaces of the thighs and upper arms, but there is not any typical localization such as the abdomino-femoral rash of smallpox. The other features of scarlet fever—sore throat, vomiting, and furred papillated tongue—are usually absent, but all three may be present in severe attacks, adding considerably to the difficulty of accurate diagnosis. The rash is usually transient, is not blanched by intradermal injection of anti-scarlatinal serum, and is not followed by desquamation. The urticarial and morbilliform rashes are usually mild and fleeting. From 3 to 5 per cent of cases show a prodromal rash of some sort.

Eruption

As the prodromal rash, should there be one, fades, the characteristic varicella eruption begins to appear; it begins on the front and back of the chest and abdomen and on the inner sides of the thighs, in the form of pink macules or maculopapules, fading on pressure and not unlike the rose spots of typhoid fever. The papular stage is frequently brief in many of the lesions, changing to well-formed vesicles in a few hours. In the course of the next twelve to twenty-four hours the face, scalp, and proximal parts of the extremities are invaded and, during the next few

days, up to a week from the onset, fresh lesions appear in successive crops, each accompanied, not infrequently, by a rise in temperature. At this stage itching may be severe, especially in adults. In an appreciable proportion of cases the eruption appears on the mucous membranes of the fauces, palate, and pharynx; exceptionally it invades the conjunctiva, larynx, vulva, or prepuce. The life cycle of individual lesions is so variable that many lesions of the same age may look very different from each other at the end of twenty-four hours. Some remain maculopapular or recede rapidly, others become fully developed turgid vesicles, while a few will have already collapsed or ruptured, with early crust formation.

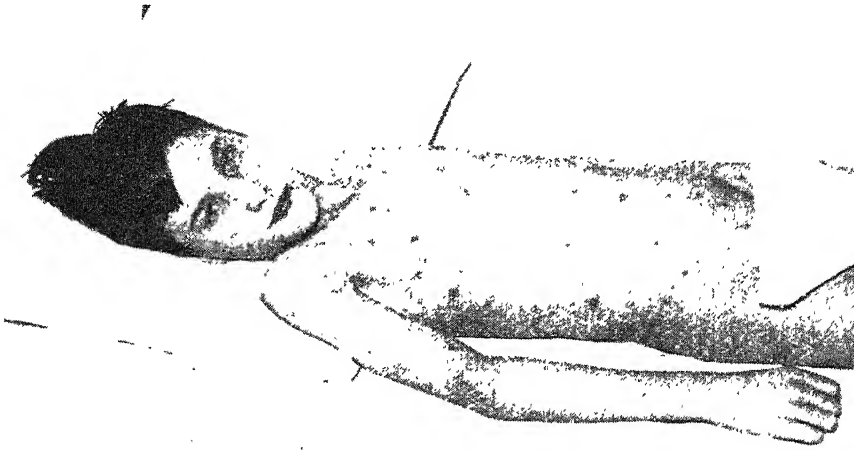


FIG. 9.—Case of chicken-pox, showing typical distribution; lesions vary in size and stage of development; many are surrounded by an erythematous areola; and lesions at the elbow show a pale zone around each pock

The majority are rounded or oval with irregular or crenated margins; they seem to be situated on the skin rather than in it (see Fig. 9). Such a lesion is just palpable to the touch and is best appreciated when pinched with the fingers.

In a few hours vesiculation appears in the centre of the papule, and in twenty-four hours or a little longer the process is complete. Some vesicles are ruptured early, either spontaneously or from trauma, but the majority take on a pearly hue from opalescence or turbidity of the contents. In a day or so the colour becomes creamy or brownish, and dimpling or spurious umbilication appears in the larger lesions. *Vesicles*

Vesicles usually show a narrow erythematous zone or areola around their margins. This areola may be much wider than the diameter of the vesicle, and fade gradually into the surrounding skin at its periphery. Less frequently no areola is present and the vesicles look like glistening drops of glycerin on the skin surface. Occasionally at the earlier stages areas of pallor surround some lesions.

While most of the lesions are round or oval, in certain situations they vary greatly in size and contour. Where the skin is thin, and especially where the natural skin-folds are pronounced, as in the inguinal and axillary flexures, the lesions are commonly elongated or elliptical, their long axes lying parallel to the skin creases. Faint striae are seen on the surface of the vesicles parallel to their long axes; these may be made more evident by stretching or pinching the thin covering. Should scarring ensue, this elliptical shape is helpful in making a retrospective differential diagnosis from smallpox, in which disease the lesions and scars are always circular. On the face, scalp, and extremities, however, the varicella lesion is circular, frequently remaining papular for a day or two and firm and 'shotty' to the touch. In these situations dimpling of the lesions is most likely to occur.

Pustules

On the second or third day the contents of the vesicles change from turbid fluid to pus; the pustules become firmer and the margins may be rolled, showing well their wavy, crenated outline. At this stage an erythematous areola may appear for the first time, due to increased vascularity from leucocytic infiltration or to pyogenic invasion.

During the next few days the contents are inspissated and the pustules gradually dry up and form superficial scabs. In uncomplicated lesions the scab falls off in a few days leaving a pink area, approximating in size and shape to the original maculopapule. The whole process is completed in ten to twenty-one days, depending on the severity of the lesions. The pink base may remain visible for many weeks or months, but gradually becomes paler and is lost in the surrounding skin. Many lesions, however, remain as pale or white clearly recognizable areas, and, where there is destruction of the true skin, the tell-tale scars remain for the rest of life. In the great majority of cases a few such scars may be seen on the trunk or on the forehead, if carefully looked for.

Absolute distribution of lesions

The lesions appear first in the buccal cavity, on the palatal, faucial, and pharyngeal mucosa. They are difficult to identify in the maculopapular stage and must be looked for in a good light. In the vesicular stage they are readily seen as small grey erosions with a bright red margin. They are not so constant as in smallpox, but their presence excludes many of the other skin diseases which may confuse the diagnosis. The enanthem sometimes spreads to the larynx and trachea and may cause hoarseness or symptoms of suffocation from oedema of the laryngeal mucosa. Lesions occasionally appear on the conjunctiva; less common sites are the vulva, urethra, and prepuce.

The exanthem usually appears first on the chest and back, and thereafter on the abdomen, spreading peripherally to the flanks and axillae. Several crops may have come out before lesions appear on the face and scalp, but very occasionally lesions are seen first on the face. Lastly, the extremities are involved, the earliest lesions appearing on the proximal parts. Frequently the palms and soles escape, but in severe cases lesions may be fairly numerous and deeply seated in both

situations, and remain in the papular stage for several days. In all there may be as few as two or three lesions, or as many as several thousand. Cases of average severity have about one hundred lesions when the eruption is fully developed.

Important as are the characters of the individual lesions, the order of their appearance and the mode of their evolution and the relative distribution of the lesions on the surface of the body remain the most trustworthy guides in arriving at an accurate diagnosis. A scrutiny of the rash as a whole reveals that the lesions occur in greatest profusion on the central parts of the body, and are less and less frequent as the periphery is approached; in other words, the distribution is centripetal, in sharp contrast to the centrifugal eruption of smallpox. If the face alone is examined, it will be noticed that the lesions are more profuse on the upper half, above the nostrils, than on the lower half. Similarly the lesions are more profuse on the proximal parts of the extremities than on the distal parts, which may be completely free. Certain factors may determine an increase of lesions in some locality, thus forming an exception to the rule of relative distribution, and confuse the issue. Chicken-pox shows a predilection for the sheltered parts of the body, where the skin is thinnest, as exemplified by the presence of pocks in the axillae, groins, and normal concavities of the body-surface. The converse is true, that chicken-pox avoids the prominent parts, convexities, and extensor surfaces, in sharp contrast to smallpox, in which pocks are most profuse in these situations. On the other hand, chicken-pox resembles smallpox in appearing more profusely in areas which have been subjected to pressure or irritation either during the incubation period or before it. Aggregations of lesions are therefore found around the neck, waist, and wrists if tight bands have encircled them, on the buttocks and groins of children who are subject to enuresis, and at the sites of Mantoux and Schick tests, where recent positive reactions have been obtained. Even parts of the body recently exposed to sunburn are liable to have relatively numerous lesions. Allowance must, therefore, be made for an unusual or anomalous distribution of lesions in any particular situation, and due attention paid to the main features of the rash.

*Relative
distribution
of lesions*

5.—CLINICAL TYPES

The ordinary, benign form just described is seen in the vast majority of cases; it varies in severity and in the profusion of lesions from one or two to several thousand, with confluent pustules in some situations. The mortality is practically nil.

Benign form

The severe form is usually subdivided into three varieties, bullous or pemphigoid, haemorrhagic, and gangrenous.

*Severe
form*

In varicella bullosa the lesions may be large from the first or may rapidly develop into large blebs which are readily ruptured, leaving raw

*Varicella
bullosa*

painful surfaces. The condition appears usually to be due to an idiosyncrasy, but in some patients it is attributable to streptococcal invasion of the vesicles. Although a serious complication it is not necessarily fatal.

*Varicella
haemor-
rhagica*

Varicella haemorrhagica is equally rare. In one group haemorrhages occur into vesicles and intervening areas of skin in the form of petechiae or purpuric patches. Recovery is the rule in this form. Less frequently ecchymoses occur all over the body as well as into the vesicles, with epistaxis, vomiting of blood, and melaena. The condition is usually fatal. Haemorrhagic varicella is probably due to the presence of haemorrhagic diathesis in the individual and not to increase of virulence in the infecting agent.

*Varicella
gangrenosa*

Varicella gangrenosa is much more common than the other two varieties but appears to be less prevalent than formerly. It is usually found in debilitated children, and in association with concurrent or recent attacks of measles or scarlet fever. The lesions increase in area and in depth, and are concealed by black necrotic crusts, which, on separation, reveal unhealthy-looking, sloughing ulcers. Individual lesions may coalesce with destruction of large areas of skin and subcutaneous tissue down to muscle. Toxaemia from septic absorption is marked and death may occur from asthenia or from terminal broncho-pneumonia. Healing is slow and accompanied by much scarring.

6.—COMPLICATIONS

Under favourable hygienic conditions, complications are absent or negligible in healthy children. Conjunctivitis, arising from lesions on the conjunctiva, occasionally proves troublesome, but both keratitis and corneal ulceration are extremely rare. Hoarseness and aphonia may follow a lesion in the larynx and, exceptionally, may cause symptoms of suffocation. Mild grades of pharyngitis and bronchitis are not infrequent in adults.

Pyogenic infection of lesions may lead to impetigo, boils, subcutaneous abscesses, cellulitis, erysipelas, or scarlet fever. Occasionally suppurative otitis media accompanies these septic complications.

*Nephritis and
arthritis*

Nephritis and arthritis may occur in the second week, usually following the association of scarlet fever and chicken-pox, but also, exceptionally, complicating chicken-pox alone.

*Nervous
complications*

Considerable attention has recently been directed to the nervous complications of chicken-pox. A few cases have been reported of encephalomyelitis, histologically identical with the form associated with vaccination, smallpox, and measles, occurring at intervals of seven to fourteen days from the onset of varicella. The condition is ushered in suddenly by headache and dizziness or mental confusion and stupor, with onset of various paralyses a few hours later. Post-varicellar cases are mild and recovery without residua is the rule. In

the present state of knowledge, it is impossible to say whether the condition is due to latent neurotropic properties of the varicella virus or whether the latter merely activates an unidentified specific virus which the patient previously harboured. Various other nervous complications, such as peripheral neuritis, poliomyelitis, and cerebellar ataxy, have been described in association with chicken-pox, but the occurrence of these disorders is probably a mere coincidence, without casual relation to the primary disease.

Authenticated second attacks are rare. To the inexperienced the scars left by pustular and impetiginized lesions of other diseases may closely resemble varicella marks. There are few cases on record of undoubted attacks of chicken-pox witnessed on both occasions by the same observer. *Second attacks*

7.-ASSOCIATED DISEASES

The relationship between herpes zoster and chicken-pox was noted by von Bokay as long ago as 1909. Some workers still regard it as merely accidental, but the weight of the clinical and epidemiological evidence has increasingly favoured an aetiological connexion. This has been supported in recent years by the serological studies of Amies (1934) who confirmed the presence in zoster vesicles of elementary bodies morphologically similar to varicellar bodies, and demonstrated by cross-agglutination experiments a close serological affinity between the two viruses. This affinity had previously been suggested by the work of Brain who carried out complement-fixation tests with both varicella and zoster sera, using suitably diluted zoster vesicle fluid as the antigen. *Herpes zoster*

On the clinical side, numerous observers have had experience of instances of chicken-pox developing ten to sixteen days after exposure to herpes zoster. So frequent is this occurrence that it is now the usual practice in fever hospitals to isolate all cases of zoster immediately they are recognized. Less frequently, zoster and varicella lesions appear side by side in the same patient, either concurrently, or the former appearing a few hours or a day or two previously. The sequence of herpes following chicken-pox is very rare, not more than twenty well-authenticated cases having been recorded. The arguments commonly adduced to refute the relationship between chicken-pox and zoster, namely, the different age and seasonal incidence of the two diseases, cannot be held to have any real force.

The scarlatiniform prodromal rash of chicken-pox is frequently mistaken for scarlet fever. The differential diagnosis is rendered more difficult by the occasional simultaneous appearance of the two diseases. The varicella virus appears to be capable of rousing into activity haemolytic streptococci which the patient may harbour, with production of exotoxin and a general erythematous rash. The diagnosis is confirmed by isolating streptococci from the throat in large numbers or in pure *Scarlet fever*

culture, and by observing the Dick response change from positive to negative. In some cases, the scarlet fever rash appears later, in the late vesicular or pustular stage, and is associated with streptococcic invasion of the lesions. Haemolytic streptococci are readily isolated from the inflamed pustules but their aetiological significance is not always easy to assess. Scarlet fever may develop at any stage of an attack of chicken-pox, from contact with a carrier of streptococci or an acutely ill patient suffering from scarlet fever. The prognosis when the two diseases are associated is always less favourable; there is a definite tendency to pyogenic infection of the lesions on the one hand, and to haemorrhagic nephritis on the other.

Apart from the rash of scarlet fever, various accidental or concomitant rashes may from time to time be encountered. These may be scarlatini-form, purpuric, morbilliform, or pleomorphic, and are generally attributed to toxic absorption from the infected lesions or to increased sensitivity of the cutaneous surfaces.

Marasmus

In the presence of marasmus and debilitating diseases, the varicella may be mild, but definitely tends to be severe, as manifested by the proneness of the pustules to spread and coalesce rather than by their numerical profusion. The lesions may be secondarily infected by haemolytic streptococci or the Klebs-Loeffler bacillus, and cultures should always be made for these and other likely organisms. When diphtheritic infection of lesions has taken place the toxæmia is severe and the prognosis grave, but cases of recovery, both with and without cardiac and neuritic complications, have been recorded.

8.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Diagnosis from smallpox

Accurate diagnosis in chicken-pox is important owing to its resemblance to smallpox. The difficulties of the differential diagnosis have been increased in recent years by the emergence of a mild type of smallpox, which, in severity of constitutional disturbances and profusion of rash, may, in the adult at least, be surpassed by chicken-pox. In investigating a rash of doubtful character inquiry should be made regarding a previous attack of chicken-pox and an examination made of the whole surface of the body, especially the brow and axilla, for the characteristic scars of varicella as well as for the marks of vaccination. The patient should be interrogated about the possibility of exposure to chicken-pox, zoster, or smallpox during the preceding three weeks. The prodromal features are important; although the initial symptoms of chicken-pox in the adult may be as severe as of smallpox they do not last as long as three days and backache is never very intense. As regards the actual eruption, mere profusion is no guide. Indeed at the present time a very profuse rash in an adult is more likely to be chicken-pox than smallpox. The character of the individual lesions is carefully examined, but all the usual criteria, with the exception of the relative distribution sign, may

fail. If the lesions are sparse or, although profuse, should some doubt remain with regard to the distribution, an outline diagram of the body surfaces upon which the lesions are plotted is very helpful. By this device the centripetal distribution of the varicella eruption is readily differentiated from the centrifugal arrangement of variola lesions. Localized aggregations of lesions, due to such stimuli as pressure, exposure, or trauma, are easily recognized and seen in their proper perspective in the general pattern of the rash.

Less frequently, certain acute affections of the skin occasion difficulty in the differential diagnosis. *From skin affections*

In papular urticaria the characteristic lesion is the papule, but occasionally the lesions may be partly or wholly vesicular. The predilection of the lesions for the extremities, especially around the wrists, differentiates it from chicken-pox, and the absence of lesions from the buccal cavity excludes smallpox. A history of previous attacks and the marked tendency to itching are useful points in the diagnosis. *From papular urticaria*

In impetigo the face and exposed surfaces are usually affected and there is a tendency to grouping of lesions and rapid formation of yellowish crusts which tend to re-form on removal. The lesions are commonly larger than in chicken-pox, but difficulty may be experienced if the varicella rash is of a few days' standing and is secondarily infected with impetigo. Though the lips and oral region are frequently involved in impetigo the buccal mucosa is not affected. *From impetigo*

The lesion of pemphigus is large and is not surrounded by an erythematous areola, such as is usual in varicella lesions, nor do the lesions pass rapidly through the regular changes which characterize the varicella. The condition is relatively uncommon and recurrences are prone to occur. *From pemphigus*

The lesions of molluscum contagiosum persist for a considerable time and are elastic to the touch. The tops are flattened or dimpled and a translucent mass can be expressed from the bodies. *From molluscum contagiosum*

Dermatitis with pustules may occur in a number of conditions, including scabies. Sometimes the pustular stage of varicella is closely imitated, but recognition of the primary disease or the anomalous distribution of the lesions usually provides the clue to the condition. *From pustular dermatitis*

In dermatitis herpetiformis vesicles appear in crops and often form clusters, but they do not pass through a pustular or scabbing stage unless they are secondarily infected. The disease is rare except in adults and recurrences are frequent. *From dermatitis herpetiformis*

Among rarer conditions which may occasionally give rise to difficulty in diagnosis are erythema multiforme, hydroa vacciniforme, prurigo, the varicelliform syphilide, and iodide and bromide pustular eruptions. *From other rarer conditions*

Not infrequently chronic skin conditions, such as acne and eczema, are considerably improved by an attack of chicken-pox.

9.—TREATMENT

During the pyrexial phase, and in children until desiccation has taken place, the patient should remain in bed and be strictly isolated. Diet should be light and simple and aperients ordered as necessary. If the rash is profuse, or irritation marked, the patient should be sponged twice daily with boric acid solution—1 ounce of boric acid to 1 gallon of water. Otherwise the daily bath or blanket bath is sufficient. The lesions may be dusted with zinc and boric acid powder, but in uncomplicated cases the less they are interfered with the better. Children usually require to have the arms restrained in cardboard or other light splints and the hands encased in fingerless gloves to prevent scratching and infection of the lesions. If the scalp is heavily affected the hair is with advantage cut short.

Lesions which are only mildly inflamed are conveniently painted with strong solution of iodine, twice or thrice a day; mercurochrome 2 per cent, tannic acid 5 per cent, or potassium permanganate 1 per cent, serve equally well but have no special therapeutic virtues. Should considerable inflammation ensue, hot boric fomentations are applied to the affected areas. If impetigo is grafted on to the lesions warm olive oil or poultices of boric acid and starch are invaluable in removing the crusts prior to the application of diluted ammoniated mercury ointment. In varicella gangrenosa immersion in eusol or boric acid solution baths is the best measure. When scabs have formed no attempt should be made to expedite matters by removing them. If removed too early they tend to form again. The raw surface is also liable to secondary infection with the risk of subsequent scar formation.

Prophylaxis

With the exception of measles, chicken-pox is the most infectious disease affecting children. Infectivity is at its maximum a few hours before the appearance of the eruption and rapidly declines in the course of the following week. By the tenth day the majority of cases are innocuous even although pustules may persist. Dried scabs do not seem to be infectious. Nevertheless it is still the accepted practice in chicken-pox, as in smallpox, to keep patients isolated until the scabs have separated and the epithelium firmly healed, paying particular attention to the scalp. When the sick-room is vacated bed-clothes and garments are disinfected by boiling or in the steam disinfecter. The walls and furniture are washed with soap and water and the room thoroughly aired.

Active immunization

Indifferent success has attended attempts to confer immunity by means of varicellization. Sometimes a general eruption indistinguishable from natural chicken-pox follows inoculation, but more frequently the inoculum fails to take. Until more refined methods are available, the procedure can hardly be regarded as justifiable.

Passive immunization

The efficacy of immune convalescent serum in affording temporary protection is not yet established. While such protection is not so urgently required in chicken-pox as, for instance, in measles, it is often very

desirable in institutional outbreaks for administrative reasons. Carefully controlled experiments have shown that doses double those found adequate in measles prophylaxis do not ensure successful protection in all cases. A possible explanation is the occasional occurrence of a weak or inert serum, which, when added to a batch of pooled sera, seriously lowers the protective value of the final product.

The quarantine period is commonly taken as twenty-one days. This *Quarantine* should certainly be extended to twenty-three days in institutional outbreaks. It is unnecessary to apply quarantine measures for the first ten days following exposure.

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CHIGOE DISEASE

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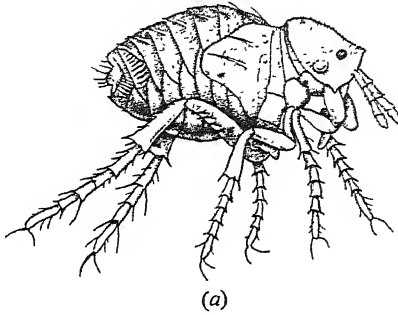
Reference may also be made to the following title:
ARTHROPODS AND DISEASE

1.—DEFINITION AND AETIOLOGY

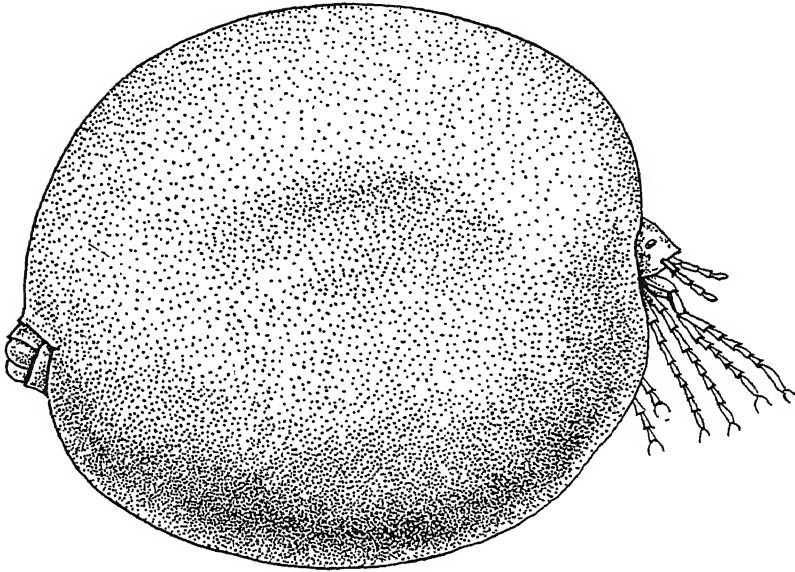
The organism 229.] The chigoe, jigger, or sand-flea—*Tunga* (*Pulex*, *Sarcopsylla*, or *Dermatophilus*) *penetrans*—is a small, 13-segmented flea, red-brown in colour, about 1 mm. in length, which has acquired for itself some importance from the fact that the female of the species burrows into the skin of man causing much disability and opening the road to other infections. It must not be confused with the mite to which the name ‘jigger’ is sometimes given in northern America. The name *Tunga* given by Jarocki to the chigoe has a year’s priority over *Dermatophilus*.

Life history The adults of both sexes live in dust, either in the house or in the sandy soil without, and feed at intervals on man or any other warm-blooded animal, with a predilection for the pig and the domestic fowl. The female after impregnation forces her way into the epidermis of her victim and there, unless extracted, rapidly becomes distended with ova to the size of a small pea, all the segments except the head and two tail segments being enlarged (see Fig. 10, *a* and *b*). The little bag of eggs is surrounded by a layer of the stratum lucidum, the head is buried in the dermis, and the tail segments block the tiny opening in the skin. Rather more than a week later ripe ova are expelled through the skin aperture or they may come away through an opening caused by ulceration of the skin over the swelling. The eggs are oval in shape, pearly white in colour, and measure 0.5 by 0.3 mm. The number which may

fall from the skin of a heavily infected patient in twenty-four hours is enormous. Three or four days after the egg has been laid the larva hatches out, by means of an 'egg-breaker' with which it is armed, and appears as a white, active, footless maggot with a head, three thoracic and ten abdominal segments covered with sparse hairs; it feeds upon



(a)



(b)

FIG. 10.—The chigoe (*Tunga penetrans*). (a)—mature female, not impregnated, size approx. 1 mm. (b)—impregnated female, measuring up to 10 mm.

what it finds in the dust in which it lives, including the dejecta of the adult.

Two ecdyses only occur, the first five to eight days after the egg is laid. Preparation for pupation takes place on the sixth to seventeenth day and pupation on the tenth to eighteenth day; the imago emerges usually about the seventeenth day.

The chigoe was first noted, it is believed, by Orviedo in 1551. It was *Historical* described by Antonio Galvão before 1557, by Gaspar Afonso who went to Brazil in 1596, and by G. Soares de Sousa in 1587. By the South

*Original
distribution*

American Indians the insect was known (in the Tupi language) as *tungaçu*, a word meaning 'big flea'. It was in those days confined to tropical America, 30° N. to 30° S., including Brazil, Argentina, Central America, and Mexico, whence it spread to the West Indies. Bermuda, at one time affected, is now free of this pest.

In Africa

In 1872 the chigoe appeared in West Africa conveyed thither by the British ship *Thomas Mitchell*, Bahia to Ambriz (Angola), which unloaded sand ballast on the shore, instead of into the sea, contrary to regulations. From Ambriz the scourge spread to the north and south and had reached seventy miles inland in 1875. By 1895 it had crossed the continent and arrived in the various territories of East Africa, in 1906 the Sudan and thence Egypt, Tunisia, and Algeria. Abyssinia was invaded between 1920 and 1924. To the south, via Rhodesia, the Transvaal was reached in 1912. Going further east it was noted in Seychelles in 1915 and Madagascar in 1900.

In Asia

This flea also found its way to Asia Minor and Syria and in India (1899) to Bombay and Karachi, but does not appear to have spread.

*In Far East
and U.S.A.*

It is also stated to have been introduced into the Far East on the one hand and into the United States on the other.

2.—CLINICAL PICTURE

In the European the chigoe generally attacks the skin at the side of the nail of the little or fourth toe, but any part of the foot may be the site of infection. The same is true of the native, but, whereas in the white man seldom more than two or three will be found at any one time, in the coloured races, especially among the children, the infection may be very heavy and the soles of the feet and the toes may be literally honey-combed by the ravages of the female flea. Unable to walk in consequence, the child takes to shuffling about on its buttocks and hands and these in their turn become infected together with the thighs, scrotum, penis, and perineum. No part of the body, not even the face, is immune from attack. The first symptom, and one felt by a sensitive person almost as soon as the flea begins to burrow, is an itching which soon becomes intolerable and leads to scratching of the part. At this stage the chigoe may be removed before she has become distended with eggs. Later, with ovulation the flea becomes little more than a bag of eggs. The irritation is severe, and the inflamed part is a livid purplish-red; in the case of the little toe, engorgement of the digit may become so pronounced as to threaten strangulation.

If the chigoe is not removed at this stage ulceration occurs, which may prove troublesome, before the body of the flea is evacuated and healing takes place. The breaches of surface may allow the entry of pyogenic cocci and the tetanus bacillus.

3.—TREATMENT

Preventive measures should always be carefully observed in all areas *Prevention* where chigoes are found. The house should have cement floors which can be easily swept, and washed with disinfectant. Native servants should be instructed in the care of their own feet. The European should never go about barefoot even in the bedroom, and bedroom shoes rather than slippers should be worn while dressing. Pigs, cattle, and poultry should be segregated at a distance from dwelling-houses. When travelling, it is necessary to avoid infected villages and native huts, and the same applies to many European rest-houses.

Anointing the feet with an ointment of lysol, 5 drops in yellow soft paraffin 1 ounce, or of salicylic acid 60 grains, ichthammol 4 drachms, yellow soft paraffin 4 drachms, will help to repel these insects. As soon as infection occurs the chigoe should be removed, and experience shows that the operation is best left in the hands of a native servant, many of whom perform this service with great skill.

The part is sterilized with ether, alcohol, solution of iodine, or solution of metaphen (1 in 1000); by means of a blunt needle the skin is then slowly pressed away from the chigoe, which in this manner is completely exposed and removed. Care must be taken not to rupture the body of the chigoe during this process. A small dressing may be necessary for a few days.

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CHILBLAINS

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1.—DEFINITION AND AETIOLOGY

230.] Chilblains occur after exposure to cold, particularly in wet or damp weather, and in most cases they completely disappear with a change of weather. This response is dramatic and is of diagnostic importance, as, for instance, in distinguishing between chilblains and lupus erythematosus.

The effect of cold on a normal skin is to dilate the capillaries and small veins, giving rise to a diffuse hyperaemia. This is accompanied by a contraction of the small arterioles. In some persons repeated application of cold establishes this condition more or less permanently, causing what Haxthausen described as *perniosis*, or the chilblain circulation. In these subjects there is a follicular hyperkeratosis, thickening of the horny layer, and often diffuse redness together with punctate haemorrhages and capillary aneurysms. These changes are most obvious on the outer side of the lowest third of the leg, and on the back of the upper arms.

Cold, however, cannot be the only factor, since only a proportion of individuals equally exposed are affected; chilblains are moreover most frequently found between the ages of seven and twenty and the majority of sufferers cease to be troubled after attaining twenty-five to thirty years of age. Hallam (1931) in an article entitled 'The Enigma of the Chilblain' frankly admitted that the disposing causes are as yet imperfectly understood. Almroth Wright found that the coagulation time of sufferers from chilblains was delayed. Biochemistry, however, has not produced many further contributions towards elucidation of the prob-

lem. It is particularly noteworthy that recent studies do not suggest that there is any calcium deficiency as shown by blood-calcium estimations; in fact the blood does not show any constant chemical abnormality.

Anaemia, focal sepsis, tuberculosis, and endocrine disturbances are usually quoted as disposing factors. Anaemia and focal sepsis are not of very great importance, though isolated cases occur in which the cure of these conditions is followed by improvement.

Tuberculosis deserves some consideration. Some French authors have gone so far as to regard chilblains as a definite tuberculous manifestation. Undoubtedly erythema induratum or Bazin's disease frequently occurs on a perniotic background. The modern conception is, however, that the tubercle bacillus settles where the conditions are suitable.

2.—CLINICAL PICTURE

The legs in chilblains present a familiar picture which has been called among many synonyms 'erythrocyanosis crurum puellarum'. In cases of moderate severity there is a bluish cold patch, about the size of the palm of the hand, above one or both malleoli. A certain amount of thickening is often present and dilatation of the capillaries is visible, which can with difficulty be obliterated by pressure.

Most sufferers from erythrocyanosis crurum puellarum have a tendency to chilblains, and conversely some chilblain sufferers show the condition described above. The underlying cause in both cases is an abnormal tendency of the skin to be affected by cold. The leg condition has come into prominence during the last ten to fifteen years owing to the enormous increase of cases due to the widespread custom of wearing silk stockings.

Barber divided chilblain sufferers into two groups: (1) the fat, phlegmatic type with dry thickened skin and dull mentality, and (2) the thin type with nervous temperament and poorly developed musculature. In this latter group there is a high susceptibility to infections, focal and otherwise.

3.—TREATMENT

The uncertainties and diverse views of the pathogeny of chilblains are reflected in the many expedients that have been proposed for its treatment. Their number is indeed sufficient witness to their incomplete efficacy.

According to Haxthausen 'there is no remedy known at the present time to work specifically, when given internally, upon the perniotic vascular changes, so that the majority of therapeutic measures aim either at combating any existing pathological condition which might predispose towards perniosis or to increase in some way the resistance of the skin against the effect of cold'.

*General
measures*

The first essential is obviously to protect the exposed parts as far as possible from cold. This, however, entails thicker stockings on ankles already rather swollen, and is not very acceptable advice. Such general measures as fresh air, exercise, and sunlight are undoubtedly beneficial. Fresh air and sunlight particularly have probably a specific effect in toning up the skin and in aiding it to perform its primary duty of acting as a heat-regulating apparatus; but obviously they can only be applied prophylactically, i.e. in the summer. General irradiation of the whole body, preferably by the carbon-arc lamp, is both theoretically indicated and of proved value. The best time for treatment is October, and a fair degree of pigmentation should be achieved. If circumstances permit, a less systematic continuation course throughout the winter is desirable. Actinotherapy and heliotherapy have complex effects, and there is good reason to suppose that they produce their benefit in part by stimulating the endocrine system. Diet should be regulated on general lines—there is no specific diet. Adequate vitamin intake and avoidance of constipation are the chief considerations.

*Drug
treatment*

Calcium preparations have long been in general use since they were originally suggested by Wright. A perusal of some of the manufacturers' brochures would suggest that they are a specific, but there are ample grounds, both clinical and theoretical, for viewing these claims with some scepticism. First, although the normal calcium content of the blood is approximately 10 mg. per 100 c.c., considerable variation is apparently compatible with normal health. Secondly, sufferers from chilblains do not show hypocalcaemia and, indeed, the reverse is the case (Grove and Vines; Percival and Stuart). Thirdly, calcium per os alone has not any demonstrable effect on the blood calcium, although when injected it does, temporarily at any rate, increase the blood calcium. In face of these facts it is difficult to account for the immunity from chilblains which some sufferers undoubtedly do experience while ingesting calcium.

Calcium

Barber recommends calcium and cod-liver oil in the thin, nervous type of chilblain sufferer, but adds that its trial in both types is justifiable. A course of calcium injections at a time when the chilblains are at their worst and the weather constantly cold will definitely show whether calcium treatment is beneficial in a particular case. If benefit occurs then calcium should be taken orally throughout the winter and re-started in the following October. If calcium is given either by injection or by mouth vitamin D should be given at the same time, since this greatly facilitates its absorption. A suitable dose of calcium by the mouth is 30 to 60 grains of calcium gluconate or lactate three times a day. Intravenously calcium gluconate (10 c.c. of a 10 per cent solution) may be given every three days; or intramuscularly colloidal calcium (2 c.c.) may be given at the same intervals.

*Organo-
therapy*

The results of organotherapy are very uncertain. Thyroid extract is much recommended; Barber found it of the greatest value combined with iodine in the fat phlegmatic type. Ingram also recommended it.

It is most effective in adolescent women with slight thyroid deficiency. Ovarian extracts are on the whole disappointing. Parathyroid extract has been suggested on the ground that it regulates calcium metabolism. If, therefore, calcium therapy is being attempted, its use is rational.

A large number of local treatments, though not curative, give considerable relief. Unfortunately, however, they must be persevered with for a considerable time and are therefore time-consuming and expensive. *Local treatment*

The effect of physical measures is more or less uniformly to produce an arterial dilatation and counteract the contraction which, as has been seen, is an essential feature of the pathology. Ultra-violet light, limited to the chilblain area, is of great value, particularly when combined with general irradiation. Diathermy, the hand placed flat on one electrode in a shallow tray and the other electrode applied to the arm, is both rational and effective. A preventive course of twelve or fifteen treatments to hands and feet at the beginning of the winter acts well in many cases. Barber advised faradic baths. Humphris reported excellent results from hot-wax baths. *Physical measures*

Freezing with ethyl chloride or light application of carbon-dioxide snow is a paradoxical measure which is, however, frequently most successful. Its rationale is that the intense application of cold produces a fully blown 'triple response' of Lewis with an arterial dilatation which persists for a considerable time.

In chilblains of the fingers Jacquet recommended that the patient should several times a day raise the hands and, while they are raised, actively flex and extend the fingers for several minutes. *Mechanical measures*

Since elastoplast bandages have been so much used for varicose conditions it has been observed that they have had very beneficial effects on concurrent chilblains. It is true that these effects may be partly due to the extra warmth, but pressure itself is an effective measure. *Pressure*

Mitchell recommended a tight covering of rubber glove cut to fit the chilblain area, left on for three days. He stated that he had cured himself and life-long sufferers by this comparatively simple method.

Ointments are purely palliative. Their chief use is to alleviate the burning and itching which are common subjective symptoms and to aid healing of broken and necrotic surfaces. The drugs usually recommended are carbolic acid, menthol, ichthammol, iodine, resorcinol, tannic acid, and silver nitrate. For unbroken surfaces a paint is the easiest method of application; the following are traditional prescriptions: *Ointments*

- | | | | | | |
|------------------------------------|---|---|---|---|--------------------------|
| (a) Menthol | - | - | - | - | 240 grains |
| Compound tincture of benzoin | | | | - | 1 fl. ounce |
| (b) Ichthammol | - | - | - | - | 60 grains |
| Tannic acid | - | - | - | - | 60 grains |
| Resorcinol | - | - | - | - | 60 grains |
| Water | - | - | - | - | to 1 fl. ounce (Macleod) |
| (c) Strong solution of iodine B.P. | | | | | |

When the skin is broken, and particularly if secondary infection is present, it should be treated first for a few days with wet compresses of hydrogen peroxide $2\frac{1}{2}$ volumes, or of 3 per cent boric acid solution.

The following ointments can then be used:

(a) Balsam of Peru	—	—	— 240 grains
Silver nitrate	—	—	— 15 grains
Spermaceti ointment	—	—	— 480 grains (Leistikow)
(b) Ammoniated mercury	—	—	— 10 grains
Ichthammol	—	—	— 10 grains
Zinc oxide	—	—	— 120 grains
White soft paraffin	—	—	— 480 grains (Marland)

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CHILDBIRTH

See LABOUR; and PREGNANCY

CHILD GUIDANCE

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Reference may also be made to the following titles:

CHILD HEALTH AND WELFARE
INTELLIGENCE TESTS
PSYCHONEUROSES

1.—DEFINITION

231.] Child guidance is that branch of clinical medicine which deals with the diagnosis, treatment, and prevention of disorders of behaviour and personality in children. These are now recognized as important (1) because they are often the early signs of developing nervous and mental trouble, and (2) because, although the treatment of the more serious forms is a highly technical matter, it is possible for the practitioner to diagnose them when they are present and to give helpful advice in many cases.

2.—CLASSIFICATION OF BEHAVIOUR DISORDERS

The form which the symptoms take varies with the personality and training of the child and the acuteness of the disturbance. They fall into five main groups: (1) *Neurotic*. Tics, obsessions, phobias. (2) *Habitual*.

Enuresis, thumb-sucking, nail-biting, masturbation. (3) *Delinquencies*. Stealing, lying, truancy. (4) *Exaggeration of normal behaviour*. Violent tempers, aggressiveness, offensiveness, rudeness, timidity, shyness, lack of confidence. (5) *Educational difficulties*.

3.-AETIOLOGY OF BEHAVIOUR DISORDERS

Behaviour is the response of the individual to his environment and so it depends on the nature of his surroundings and upon his mental endowment and training. The surroundings must be evaluated as he sees them, not necessarily as they are. The dark room is empty, but it frightens the child because his imagination fills it with frightening things and so he is not silly to be frightened. The forces that modify behaviour are emotional rather than material and actual. Relationships between parents and children are greatly influenced by this. A father may be big and powerful but, if he has a changeable nature, he may arouse a feeling of intense insecurity in his child, when superficially it might be supposed that he represented a tower of strength. It is of fundamental importance to remember always that atmosphere and attitudes are of much greater importance than actual conditions and events. A child who is apparently made nervous by a sudden shock, such as a dog-bite, was quite surely nervous before and the incident has merely brought it to the surface.

Early training

The same holds good in respect of early training. A child develops a personality and behaviour responses not as a result of isolated experiences but from the general tone of his surroundings. If he has grown up in an ordered, secure, and reliable home, he will be calm, logical, and even-tempered. Should great anxiety have been constantly around him, he will develop anxious, fearful tendencies. A home where inconsistent handling, frequent change, and unreliability are the rule will train him to be an opportunist, always ready to take advantage of the emergency and quite unable to plan ahead.

Inheritance

Ability to respond satisfactorily, or in other words to behave well, depends to some extent on congenital mental endowment. Some are born with unstable temperaments, but far more develop instability, and heredity is blamed for many errors of training.

The amount of mental inheritance is a much more serious factor and can be estimated with a great degree of accuracy. Every child matures during the first decade and a half of his life, but the rate of progress varies in each individual. It has been found that achievements develop in definite directions at the same time in the majority of children, but some progress more quickly while others lag behind. By standard tests the amount of advance or retardation can be measured and expressed as a quotient. Taking the normal as 100, if a boy of ten were found to have the intelligence of the majority of boys of eight, then his intelligence quotient would be 80, while, if he were as advanced as the normal boy

of 12, it would be 120 (see INTELLIGENCE TESTS). Realization of these discrepancies is most important and, when dealing with any problem of behaviour, it is essential to know the exact intellectual development of the patient. The estimate of the teacher or ordinary observer is not enough and it is worth the practitioner's while to practise the use of a few standard tests.

Childish behaviour often arises from childish development, but the effect of the opposite, unusually high intelligence, is too seldom recognized. The majority of over-anxious, excited, noisy children are suffering from an accumulation of nervous and mental energy which is denied a useful outlet in work. The old idea of keeping the clever child back is wrong; these children must be given interesting work, preferably in ordinary academic subjects, if they are to become stable. No harm was ever done by allowing a child to work and stimulating his interest. To drive him to work is a very different matter.

The real delinquent, who commits crimes frequently, deserves separate *Delinquents* mention. Among the whole group there are a few neurotics who have drifted into delinquency as it were by chance. They are usually easy to recognize and simple to treat. They show symptoms of anxiety, or fears, or obsessions, and in a general way they seem unusual. The ordinary delinquent, on the contrary, seems quite a usual child who has deliberately chosen the wrong path. But he is impervious to reason and does not respond to discipline; he seems to be 'incurable'. It is impossible to generalize beyond a certain point, but in the majority of cases he is found to have a fundamentally wrong attitude to life. A curious aggressive, resistive hostility seems to put up a barrier to the outer world and renders persuasion, force, or example quite impotent. The delinquent does not want help; this is reflected curiously in his learning. He may be intelligent enough to learn but seems unable to allow himself to do so. It is all part of the barrier.

This attitude probably has its origin in very early influences, which have created a deep hostility to life in general. Very often it is found that he has grown up in a broken home or where parents have been constantly at variance. The frequency of this history must be more than a coincidence. Sometimes the discord is of lesser degree, for example when the parents merely differ in their ideas on training and morals, but the disturbance is there all the same.

4.—DIAGNOSIS OF BEHAVIOUR DISORDERS

In some cases, as when fits or well-marked obsessions are present, it will be obvious that the patient is really ill; but, when the difficulty is merely one of degree, as in Group (4), it may be hard to decide whether in fact a real problem exists and whether firmness and discipline or some more indirect form of treatment is necessary.

The diagnostic features of a real problem are: (1) it cannot be corrected

by ordinary training or discipline; (2) there seems no adequate reason for its appearance; (3) it occurs at an age when it should not be present, for example, bed-wetting or thumb-sucking at the age of twelve; (4) a number of symptoms appear together, such as fear, anxiety, shyness, and failure at school; or aggression, tempers, inattention, truancy, and stealing.

Response to discipline

Before it can be definitely said that behaviour does not respond to discipline and training, the effect of these must be carefully watched over a period. Often it is stated that kindness and strictness have been tried without effect, when neither has been given a sufficiently long trial, or they may have been inconsistently applied. Discipline, if sufficiently violent, may dispel any symptom or alter any behaviour, but this often means simply that the patient has adopted a less obvious habit. Stealing, if severely punished, may give place to masturbation, and fears met with force are only driven underground. This will inevitably happen if a real problem has existed, and is why the application of very forcible correction is so often dangerous. If behaviour cannot be controlled by moderate means, it has a pathological cause and will not respond in a healthy manner to ordinary training methods.

When seeking the reason of unusual behaviour, it is easy to be misled by an obvious explanation. A child and his parents are at cross-purposes and have frequent rows. He wets the bed each night there has been trouble; clearly, it would seem, to annoy the parent. This is the superficial or obvious reason; but, if treatment is to be successful, it is necessary to know what the real trouble is—namely, why the parents and the child become hostile to each other and why the latter meets the difficulty by wetting his bed. The bed-wetting may be the result of increased anxiety caused by the row, or it may even be an unconscious attempt to annoy; but the neurotic, whether child or adult, always trades on his symptoms. The hysteric can walk to a concert but not to work. The process is quite involuntary on the part of the patient, but it happens nevertheless. A child makes a disturbance clearly to gain attention. The important point to discover is why he needs attention and why he must get it in that way. One part of the motive may seem obvious, but it is the deeper factors which are important in treatment.

Persistence of infantile habits

The persistence of a symptom, such as thumb-sucking, or in some cases bed-wetting, is a sign that the child has not grown up. When he reverts to any such habit after he has given it up for a considerable time, it is a sure indication that life has for some reason become too difficult and he has gone back to the habits of his early days to find satisfaction. That is why the occurrence of infantile habits in later life is of importance. In themselves they do not matter.

Exaggeration of normal behaviour

All the symptoms grouped in the fourth main group may occur in the normal child; it is only when they happen in groups and in exaggerated form and persist for a considerable time that they must be looked upon as serious. An isolated instance of sleep-walking or night-terror may indicate only a temporary disturbance of health or

habit, and indeed they may occur without any reason being found, but if they recur, and especially if they are accompanied by other symptoms, then they indicate deeper trouble.

5.—TREATMENT

The first step in treatment is accurate diagnosis. Every possible detail must be ascertained about the patient's antecedents, early history, physical health, mental endowment, and present circumstances. Only when this has been done is it possible to see him as a thinking, acting being, responding as best he can to the difficulties that beset him with the means at his disposal, as he has learned to use them. *Importance of diagnosis*

A history will decide whether or not he comes of healthy stock. Perhaps instability has been handed on to him and this sometimes happens; but, even though the heredity is bad, early influences are of more importance in most cases. It is essential to ascertain whether the conditions under which the early weeks and months of life were passed conduced to peace or to anxiety, whether sufficient affection was given or whether neglect and dislike gave rise to a feeling that the world was hostile. In assessing these forces it is important to remember that it is real attitudes that matter; if they are artificial, they are never of value. *History*

The mental endowment, as already has been pointed out, must be assessed. It is illogical to expect a dull child to win scholarships or even to cope efficiently with ordinary difficulties, or the highly intelligent child to plod along quietly. Frustration will disturb the one, and boredom the other. Work must be adjusted to capability, remembering that a fully active life is the basis of mental health and balance. Many more children have been injured by too little work than by too much. The patient's interests must be found, and fed as far as practicable. Every care should be taken to adjust any deviations from physical health and to build up the bodily strength. Habits of living must be regulated, and diet, rest, exercise, and sleep must be prescribed in proper proportion. *Mental endowment*

It is necessary to try to understand the environment as the child sees it and to unravel the likes and dislikes, preferences, jealousies, and the myriad emotional forces which act and react within it. Only by giving time and thought, and by seeing all the various factors through the eyes of those concerned, is it possible to do this. Human understanding is far more important than a knowledge of psychology, and sympathy too must play a large part. *Understanding and sympathy*

Once the facts have been collected and understood, they will fall into place and it will then be possible to lay them, expressed in simple everyday language, before the parent. This lays the basis for further treatment, because the parent must be the medical attendant's ally from the beginning. Blame and criticism must be scrupulously avoided; they never do any good and only prejudice success. If facts cannot be *Co-operation of parents*

altered, as when past influences are responsible, they should be mentioned, but only lightly so that the parent may not feel that the damage is irretrievable and nothing more can or need be done. It is wise to build on assets and discount liabilities as far as possible.

When the parent has been brought to see the main forces at work, he may be left to think out their connexion with a minimum of guidance. Usually he will be able with help to interpret the whole situation and suggest and carry out the necessary changes. This may seem optimistic, but in practice it succeeds, and only experience can teach how co-operative the average parent is. The importance of the fact that he has come to ask help is seldom sufficiently recognized. It means that he, too, will do his best.

Security and a reasonable amount of affection from parents and others are essential, as is a stable, consistent, and responsive environment. The child must feel that he has sound support and at the same time he must be an individual, able to develop within certain limits, yet guided and controlled by certain broad rules of living, instilled partly by example and partly by precept.

Prevention

The prevention of problems of behaviour and personality lies in the provision of certain fundamental conditions of life. These are security, affection, and occupation. Security depends upon the attitude of those under whose care the child grows up. Truth, honesty, and consistent handling all contribute, and proper discipline is important. The child who is taught the ordinary rules of living knows what to expect, and so he acts with assurance. Absolute freedom is a myth and can never be realized. It is far better to regulate a child's life reasonably; it makes him more comfortable and relieves him of the unfair burden of having to make decisions which are too difficult for him.

The natural play of affection between members of a family is very valuable and probably does more than anything else to develop the emotional side of a child's personality. When these emotional ties are excessive, then undue attachment may bring dependence and stifle emotional growth. When they are weak, then the child, feeling the absence of support, will become solitary, hostile, and unsocial. Childish parents tend to either extreme and it is often very hard to change their attitudes. In such cases the parents are the patients and every effort should be made to encourage them to develop and grow up. Outside activities and social interests, realization of responsibility, even the offer of friendship, all help in this process and it is surprising how much can be done by these means.

Occupation is a most stabilizing force. Work up to the child's capacity is necessary if mental health is to be maintained. It is here that the balancing of intelligence and education is important.

The practitioner may find it somewhat difficult at first to appreciate how general the principles of child guidance must be. It is not possible to prescribe a definite handling and treatment for any particular problem, and the roundabout way of seeking the underlying causes and

correcting them may appear unnecessarily complicated. Unfortunately for the simplicity of the subject the direct method does not succeed, and it is only by patient investigation and painstaking discussion and adjustment that really satisfactory results are obtained.

There are now numerous Child Guidance Clinics in many countries (there are 40 in England) where behaviour problems are dealt with. In most of these the 'team' method is used. A psychiatrist, an educational psychologist, and a specially trained social worker investigate the physical and mental health, the intelligence and education, and the environment of the patient. The facts ascertained are then pooled, the causes assessed, and treatment is planned and carried out. The clinical results are good and compare well with those of any other branch of curative medicine. The procedure sounds complicated, but its adoption is justified by the results achieved. Though it is necessary to adopt such methods in severe cases, many children can be relieved of suffering, and many parents saved anxiety, by the general practitioner working along the lines that have been outlined.

*Child
Guidance
Clinics*

Child guidance is a fascinating branch of medicine and its study will well repay anyone willing to spend a little time on its study and practice.

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CHILD HEALTH AND WELFARE

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Reference may also be made to the following titles:

CHILD GUIDANCE	INFANT FEEDING
DENTITION	INTELLIGENCE TESTS
PREMATURITY	

1.—GROWTH AND DEVELOPMENT

(1)—General Discussion

232.] It is impossible to discuss rationally the general health and well-being of the child without first taking into account the practical essentials of growth and development, since in these are reflected the child's proper health and progress.

In any organism the course of growth is manifested by accretions to its weight and length. From this point of view growth of the human organism as a whole represents an anthropometric problem. With this aspect in mind any consideration of the basic cellular metabolic processes may be omitted, and neither the chemical nor the biological phenomena underlying growth need be discussed in this article. It should, however, be stated that certain amino-acids and accessory food factors are absolutely essential in order that normal growth should proceed, and that a suitable balanced dietary is a fundamental necessity for satisfactory growth and development. The importance of endocrine secretions must also be emphasized, on account of the influence they exert upon both acceleration and retardation of growth.

Man, in common with other animal species, is characterized by a specific growth impulse, but the rate at which growth proceeds is not uniform, periods of rapid and of comparatively slow growth alternating until the adult state is attained. The growth process appears to be auto-catalysed, each of such periods or cycles apparently being the expression of a self-accelerated chemical process. The accelerating factor and the inhibitory factor, which later in the cycle brings about slowing of the rate of growth, both appear to be some substance or group of substances produced during the process of growth itself. As age advances the growth impulse diminishes, and the rate of growth of the individual both in weight and in length becomes less.

In the case of the growing child three cycles of growth stand out prominently. The first of these occurs during the early months, when growth takes place more rapidly than at any other time of life, with

*Rate of
growth*

*Normal
growth
cycles*

the exception of the foetal period. In the latter half of the first year a slackening in rate occurs, which is succeeded by the onset of the second period of rapid growth, taking place during the third, fourth, and fifth years. Another slackening then ensues until the onset of adolescence at the time of puberty, which marks the third period of accelerated growth. Subsequently a gradual slackening of the rate of growth again occurs, ending in that relatively stationary period which is recognized as the adult state.

*Standards
of weight
and height*

It is to measurements of weight and height that attention should be directed in assessing the proper growth of the child. Although standards may be set up for such accretions to weight and length as occur in man during the different stages of his growth, there are great difficulties in applying these universally. Biological data of great assistance in assessing normal growth and development have been accumulated, but the factors which exert an influence in causing variations must be appreciated. These will be specified later, when weight and height are considered separately. It must, however, be emphasized here that figures which have been compiled and are regarded as normal standards in one country are by no means necessarily correct as a standard when applied to a group of persons living elsewhere or under different conditions. The point of importance in regard to any individual is the general form of his own growth curve, and a normal child should be expected to progress, as far as weight and height are concerned, along a course which keeps within certain specified limits of variation from what is considered the average normal standard. Although there are differences of opinion on the subject, for practical purposes a variation of up to 20 per cent as regards weight and up to 6 per cent as regards height, from the accepted average standards, may be considered within normal limits. Even greater variations can often be easily explained, such, for example, as a considerable loss of weight resulting from an acute illness, this being relatively soon regained during the convalescent period.

*Interpretation
of weight
and height
measurements*

The point must here be made that, although increases in both weight and height are discussed in relation to growth, weight reflects more properly the state of nutrition, and height that of actual growth itself. Generally speaking, measurements of weight and height should be considered in relation to each other, rather than either separately in relation to the age of the individual, though this must also not be overlooked. Apart altogether from the question of weight and height alone, considerable variations in other standard measurements and in general development are to be expected in perfectly normal children.

(2)—Weight

At birth the average weight of a baby in England may be taken as just over 7 pounds. The main factors influencing birth-weight are race, sex (girls averaging less than boys), and possibly also the number of the mother's previous pregnancies. The nutritional state of the mother, and

her environment, also produce an effect on the weight of the new-born infant, and it may therefore be said that to some extent social status plays a part in determining physique at the very outset of life. Further, it is obvious that prematurity has a profound effect upon the weight at birth, so that the greater the degree of prematurity the less the infant will weigh.

Subsequent to birth a loss of weight ensues, and the bigger the infant the greater is the loss likely to be. Generally speaking, this loss amounts to about 11 per cent of the birth-weight. It occurs during the first four to five days, the drop in weight being as a rule greatest during the first twenty-four hours, and subsequently slackening off. The weight may then begin to rise at once, or for a day or so may remain stationary. The weight at birth is usually regained between the seventh and the tenth days of age, although in premature babies this is likely to occur much later, usually about the fourteenth to the nineteenth day. The initial loss of weight is due partly to the passage of excreta—meconium and urine—partly to loss of fluid from the skin in the form of invisible perspiration, and partly to the small fluid and food intake during the first few days of life. The actual shock associated with delivery has also been held to be a causal factor.

The weight curve

When once the weight begins to mount, its rise should continue in an even curve, the infant putting on from four to eight ounces, or an average of six ounces, weekly during the first half-year. Between six months and a year of age the rate becomes less, the gain averaging about three ounces per week. The normal full-term infant usually doubles its birth-weight during the sixth month, and trebles it about the twelfth month. By far the most important point, however, is not the specific weight of the infant at any given moment, but rather that it should achieve a regular steady gain in weight week by week, the weight-curve preferably running in a steady sweep parallel with the normal average standard, and remaining within the limits of variability previously stated. An average weight-curve for the first year of life is inserted for reference (see Fig. 11).

It is advisable that a baby be weighed once weekly until the age of a year, but more often during the first two weeks of life. After the first year weighings need not be carried out more than once a month, and for older children who appear healthy, three or four times a year will suffice.

During the second and third years a child should gain approximately five to six pounds in weight per year, from the third to the seventh year about four pounds, and thereafter from five to six pounds every year until the onset of puberty. At this time gains in weight differ considerably between the two sexes, until sexual maturity is reached. In every race there is a brief period, slightly antedating puberty, during which the average weight of girls is found to exceed that of boys. While boys are still growing relatively slowly, a pause being observed before their entry upon that period of rapid growth characteristic of adolescence,

The influence of sex

girls have already embarked upon this phase of their lives, attaining sexual maturity somewhat earlier, and temporarily getting ahead of the boys in weight. In the male, however, growth is rather greater during the period of adolescence, so that when once the rapid growth accompanying this begins to show itself, boys not only catch up on girls, but actually outstrip them in weight.

*Other
determinants*

In older children the gain in weight is not nearly as regular as is the case during infancy, and is modified by such factors as the degree

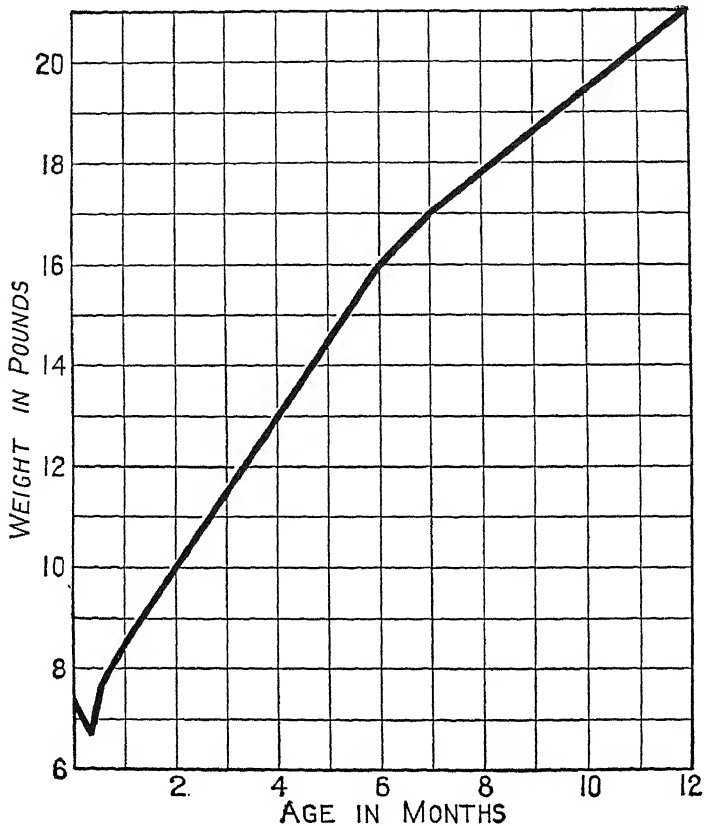


FIG. 11.—Average weight-curve from birth to one year of age
(From *Diseases of Infancy and Childhood*, edited by Parsons and Barling)

of activity of the individual. Malnutrition of necessity affects a child's weight-curve, as does overeating. It also appears that there are seasonal variations in the rate of weight increase, workers in the United States, for example, finding that the gain is generally speaking greatest during the summer and autumn months.

(3)—Height

The average length of new-born infants is twenty inches. As in the case of weight, this is influenced by race, sex, and prematurity. During

the first year the increase is nearly half of this figure, actually about nine inches. During the second year of life four inches in height is generally gained, and thereafter there is a slowing of rate until from the age of four years onwards a gain of about two inches annually occurs throughout the period of growth. At the stage of adolescence the relation of males to females in gain in height is similar to that which exists between them in gain in weight (see p. 135). It has been shown that variations in growth take place at different seasons in the year, and that exposure to sunlight stimulates increase in height.

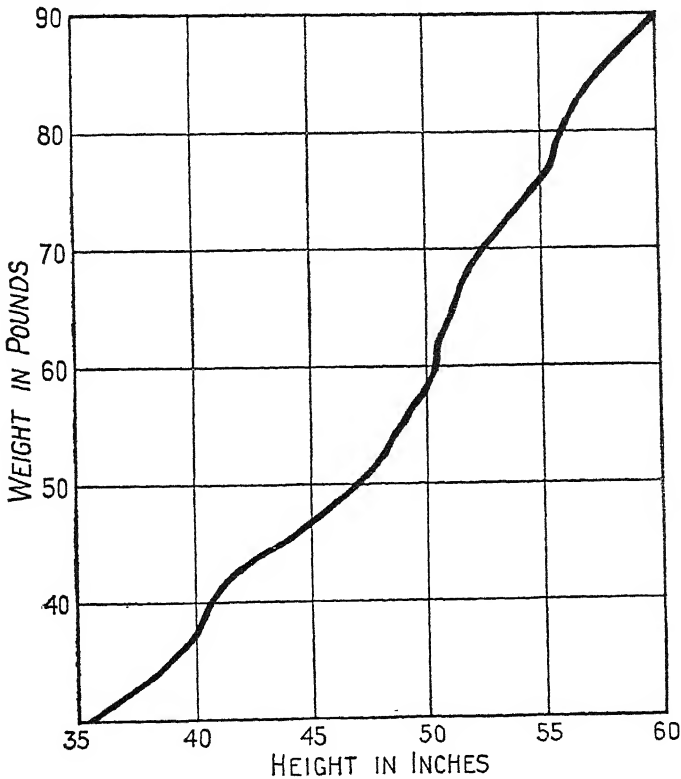


FIG. 12.—Average weight in relation to height
(From *Diseases of Infancy and Childhood*, edited by Parsons and Barling)

Gains in weight and in height usually proceed together in the normal child, but either may be influenced by the factors already alluded to, and in addition by family characteristics, which needless to say play a prominent part. Malnutrition affects weight more than it does height, and a child kept in bed on account of illness may be observed to grow in length while actually losing weight.

In assessing physical development, the relation of a child's weight to its height is of more importance than that of weight to age; above is a chart (see Fig. 12) which sets out an average relationship of this type

*Relation
between
weight and
height*

*Annual gain
in weight
and height*

and should prove of assistance, provided that the variations due to race, environment, and other factors already mentioned, are kept in mind, and that the age factor is not overlooked. A table is also reproduced which will act as a guide to normal yearly increments in weight and height throughout childhood (Fig. 13).

AVERAGE ANNUAL INCREASE IN WEIGHT AND HEIGHT *

AGE IN YEARS	BOYS		GIRLS	
	POUNDS	INCHES	POUNDS	INCHES
0-1	14.0	9.0	13.5	8.5
1-2	6.0	4.0	6.0	4.0
2-3	5.0	3.5	5.0	3.5
3-4	4.0	3.0	4.0	3.0
4-5	4.0	2.5	4.0	2.5
5-6	4.0	2.0	4.0	2.0
6-7	4.0	2.0	4.0	2.0
7-8	4.75	2.0	4.5	2.0
8-9	5.25	2.0	5.0	1.75
9-10	6.0	2.0	5.25	2.25
10-11	5.0	1.7	6.5	2.0
11-12	6.5	1.8	9.5	2.5
12-13	8.0	2.0	10.5	2.0
13-14	10.0	2.5	9.5	2.0
14-15	12.5	2.7	7.5	1.25
15-16	13.75	2.7	6.0	0.75
16-17	6.5	1.2	3.5	0.50
17-18	5.0	0.5	0.5	0.20

* The figures from birth to five years are chiefly from personal observations; those above five years are averages calculated from about 100,000 observations upon children in public and private schools in the United States, compiled from ten different authors. (From *Holt's Diseases of Infancy and Childhood*, 1933.)

FIG. 13

(4)—Body Conformation in the Child

(a) *The Head*

Circumference of head

At birth the average circumference of the infant's head is thirteen and a half inches. At first a rapid increase in size occurs, until at one year of age the measurement is seventeen and a half inches, half of this increment having been attained in the first four months. The rate of growth now diminishes, only one inch being added to the circumference during the second year, and one and a half inches during the whole period of the third, fourth, and fifth years, the circumference at the age of five being twenty inches. From then until puberty growth of the head takes place at the rate of approximately half an inch in circumference every five years.

The cranial sutures are normally open at birth, but the adjacent bony edges are usually in apposition. Definite separation of the edges is frequently seen in premature infants. By the age of seven months the sutures are as a rule ossified. *The cranial sutures*

The posterior fontanelle should close during the second month of life. The anterior fontanelle shows considerable variation in size at birth, but should measure approximately one inch in each diameter by the age of ten months, and should close between fifteen and eighteen months. It may, however, close as early as fourteen months, or remain open until the twenty-second month. If it is still open at the second birthday, this must be regarded as a sign of definite abnormality. *The fontanelles*

Asymmetry of the head is sometimes noticed at birth, but more frequently it develops later as a result of the infant lying persistently with its head in one position. As a rule this is not of any significance, normal symmetry gradually being attained in course of time. Care should be taken to vary the position in which the baby lies in the cot, or is held in its mother's arms. *Asymmetry of the head*

(b) *The Trunk*

At birth the infant's chest differs in shape from that of a fully grown person, being practically circular in cross section. As growth progresses it gradually attains the adult elliptical shape, owing to the relatively more rapid increase in its transverse as compared with its antero-posterior diameter. During infancy the head, chest, and abdomen have much the same circumference. It may be mentioned here that in the premature infant the circumference of the shoulder girdle is always less than that of the head, an important point in the diagnosis of prematurity. After the age of two years the chest enlarges more rapidly than either the head or abdomen; until about fifteen years of age it increases in circumference at the rate of approximately one inch per year. Weakly children and those suffering from obstruction to the respiratory passages are likely to have smaller chest measurements than those who are robust and healthy. *The chest*

The size of the abdomen varies greatly among healthy children; not uncommonly it is protuberant in young children who are perfectly normal. As they grow older and their muscular development progresses, it takes up a more graceful contour. *The abdomen*

(c) *The Limbs*

When compared with those of an adult, an infant's limbs are relatively short in proportion to its trunk. The limbs then grow more rapidly than the trunk, so that the central point of the body, which at birth is in the region of the umbilicus, comes to lie in the adult state at about the level of the symphysis pubis.

(5)—Dentition

This subject is discussed in the article of that title, p. 603.

(6)—Milestones of Development

As the infant advances in age and becomes increasingly active, signs of its muscular development become apparent. The rate of this development varies in different individuals, and can be assessed not by direct measurement but by observation of the way in which the infant acquires the power of carrying out its increasing bodily activities. Direct clinical examination gives a good idea of muscle tone and turgor. The following milestones will serve as a guide to the normal progress of the child, depending as they do upon both muscular and mental development:

*Normal
progress*

By the age of 3 to 4 months the infant should		grasp objects placed before him.
„	4	„ „ hold his head up alone when the body is supported upright.
„	8	„ „ sit alone without support.
„	10 to 11	„ „ stand.
„	16	„ „ walk freely.

Often an infant will learn to rush about a room by propelling itself on its buttocks, and because of the speed and ease of this means of progression is loath to learn to walk, and consequently is backward in this respect, although otherwise perfectly normal. Further, fat heavy babies are not infrequently rather late in walking. Some infants appear to be indefinitely lazy, and simply will not bother to exert themselves to make efforts which entail muscular movement.

The ages at which ossification occurs in the various centres throughout the body are not dealt with here, since they are of no clinical significance in assessing normal growth and development.

(7)—Reflexes

The deep reflexes, although often difficult to elicit, appear to be normally present from birth. Abdominal reflexes cannot usually be obtained during the first few months. The plantar reflex, it should be noted, gives normally an extensor response until early in the second year, at which time the reaction becomes flexor.

(8)—Special Senses

(a) Sight

Although the new-born infant seems able to distinguish between light and darkness, true sight is not present during the first few weeks. At this time irregular and inco-ordinate movements of the eyes occur, because the power of fixation is lacking. On this account a baby is liable to show a distinct squint at times, which may persist until two months of age without pathological significance. Strong light appears

to distress a new-born infant, but danger to sight need not be feared even if the eyes are not shielded, since from birth a reflex closing of the eyes occurs if they are exposed to strong light. After a few weeks he will follow a light with his eyes. Co-ordinated movements of the eyes occur at about three months of age. The ability to recognize persons is manifested between five and six months of age.

(b) *Hearing*

The new-born infant appears to be deaf, but within a very few days he shows signs of ability to hear. In early infancy hearing is apparently very acute, and any loud noise is liable to make an infant start as in fright. During the third month he will begin to turn his head towards the source of sounds, and often from about the fourth month he appears to recognize voices.

(c) *Taste and Smell*

The sense of taste is highly developed at birth; it has been shown that the new-born baby is able to distinguish between sweet and bitter tastes. His ability to detect changes in food is of course generally known, but there are well-marked individual variations in the degree of acuity of discrimination and the reaction to changes in taste. The sense of smell, although present in the young infant, is not very acute. It apparently develops later than the other special senses, and fine differentiation of odours is not acquired until comparatively late in childhood.

(9)—General Sensations

A new-born infant is relatively insensitive to pain and to touch, and it is not until after three months of age that he demonstrates much acuteness in regard to these sensations. He does, however, show definite evidence of discomfort if, for instance, he is left wet or cold, and colic causes the reaction of crying. Tactile sensation in the lips and tongue is highly developed at birth; this is shown by the infant's behaviour when offered his feed. The sense of temperature is present in the new-born, and a bottle feed which is only a few degrees too cold or too warm will often be refused. The sense of localization is poor until the second year of life.

(10)—Speech

Children vary extraordinarily in the age at which they begin to talk, this depending to a large extent upon the circumstances of their upbringing. Some who are obviously normal and mentally alert remain behindhand in this respect. As a general rule, however, simple words are spoken towards the end of the first year, and sentences by the end of the second. Before actual talking occurs, certain baby sounds and noises are made, but these should not be confused with true speech, despite the protestations of the parents. The names of

*Sequence of
speech
development*

objects are the first words to be learnt; next comes the use of verbs, and after this adjectives are utilized. The personal pronouns are invariably introduced comparatively late into the child's vocabulary. If at two years of age a child is not making any attempt to talk, he is almost certainly either mentally defective or a deaf-mute.

(11)—Control of the Excreta

A normal child, if properly managed and 'held out' regularly, can be trained to pass his motions at fairly regular intervals, and will seldom soil himself after the age of two or three months. At ten or twelve months of age he will usually make grunting noises to attract attention to his needs. Bladder control comes more slowly, but by the end of the first year this may be practically complete, and by two years the normal child should always be dry, except for occasional accidents, although care must still be exercised in allowing him ample opportunity to perform his natural functions.

(12)—General Mental Development

*Assessment
of mental
progress*

Any detailed discussion of this topic is outside the scope of the present article. Mental development is dependent upon a number of factors, hereditary and environmental. It is important to watch an infant for the proper attainment of the milestones of development already alluded to, and to notice his ability to recognize voices and persons, to grasp at objects, to express by his behaviour approval or disapproval, to make known his desires, and finally to talk. As he grows older, progress must be measured by a comparison of his capacity with that of his contemporaries, and later by the achievement of school standards. When necessary the accepted intelligence tests may be employed, in conjunction with a consideration of the child's general behaviour and capabilities, if difficulty should arise in assessing his mental calibre (see INTELLIGENCE TESTS).

2.—THE CARE AND MANAGEMENT OF NORMAL INFANTS AND CHILDREN

233.] In its attainment of high evolutionary status, mankind appears to have suffered a weakening of many primitive instincts, among them being the inborn knowledge of how to care for its young. Many parents recognize their limitations in this respect, and are anxious to obtain help and guidance from practitioners, whom they expect to have technical knowledge greater than their own, acquired otherwise than by mere instinct. So it comes about that, following an account of normal growth and development, a brief survey of the principles involved in the proper care of normal children is now called for.

(1)—Equipment to be provided for an Infant

(a) *Accommodation and Furnishings*

The ideal arrangement is that a child should from the beginning of his life sleep alone at night in a room without a light, the mother or nurse sleeping close at hand and within easy ear-shot. He is then accustomed to solitude in the dark and, provided that fear is not suggested to him, is unlikely at a later age to learn to fear darkness. If he must share a room with others, then he should be given first call on the available fresh air, his cot being placed if possible close to a window that can be opened wide, with a screen between it and the rest of the room, to shield him from cross draughts and from the direct glare of lamps. A separate day nursery is desirable, preferably a large cheerful room, provided with big windows receiving the maximum of direct sunlight and protected by outside bars for safety. The nursery should also be provided (a) with heating as necessitated by climate, and efficient ventilation, for which double purpose an open fire surrounded by a high fixed fire-guard may be recommended; (b) with draught-excluders for doors to minimize floor draughts, and a large movable draught-proof screen which cannot be easily knocked over; and (c) with cheerful, comfortable, but simple furniture and decorations, any fussiness or flimsiness being avoided. All paint-work should be finished in a washable non-poisonous glaze.

*Ventilation
and heating*

In a centrally heated house, radiators may be the sole source of nursery heating. Special attention must then be paid to the question of ensuring adequate draught-free ventilation, and of maintaining a proper degree of atmospheric humidity in the room.

If, as in many town flats, no balcony or garden is available for out-door sleep and play during infancy, an inexpensive caged-in platform can be fitted with absolute safety outside a suitable window. For nursery windows and balcony roofs a special glass which transmits the ultra-violet rays of sunlight is theoretically of great advantage, especially in temperate climates, but it is important to realize that any dirt or moisture on such glass considerably lessens its permeability to these rays. In a city atmosphere, therefore, thorough daily cleaning is essential if the benefits of this glass are to be obtained. The present tendency to push the sale of 'artificial sunlight' lamps for domestic use must be deplored, since ultra-violet radiation is a prophylactic and therapeutic agency which should be prescribed only by those thoroughly conversant with this aspect of physical medicine. Full details of nursery equipment cannot be discussed here, but it may be stated that there are on the market inexpensive and durable folding rubber baths, folding cots, and perambulators which close up for carriage or stairways, all of which may be invaluable for infants living in flats. Information about the appliances mentioned in this paragraph, and about where they can be purchased, may be obtained from the Association of Maternity and Child Welfare Centres, 117 Piccadilly, London, W.1.

*Open-air and
sunlight*

The cot

Whatever the structure and pattern of a cot, it should stand firmly, without rocking, and the bottom and sides should be porous, to allow of free evaporation from the region occupied by the infant. A comfortable but firm mattress (filled with bed-chaff or with freshly teased horsehair) is infinitely preferable to one that is boggy, and it is best to have either no pillow at all, or else a thin firm one into which the head or face cannot sink. Bedding should be so planned, for infants of all ages, as to allow of secure tucking in, with a comforting firm pressure exerted by an enveloping blanket or sheet over the back of the baby as he lies on one side.

*(b) Clothing**Three
general
principles*

The broad principle may be stated that clothing should be so planned that the child can wear at all ages and at all times the *least* quantity of clothes necessary to ensure that his whole body is kept comfortably warm. A second principle is that undergarments should be light and porous rather than of close texture, so as to allow air to circulate and moisture to evaporate freely from the skin. A third is that at no time should garments be tight enough to restrict growth, circulation, or freedom of muscular action in any part of the body. The further questions of appearance, fashion, expense, and practicability as regards laundering, must be considered by each individual mother in the light of these main principles. Thus it follows that the infant's binder is discarded as soon as its function of holding the umbilical dressing in place has come to an end; that a body-belt is an unnecessary encumbrance; that all forms of supporting garment such as stays, 'barriers', and bodices (including the so-called 'liberty bodices') should be banished without ceremony; that napkins, while fulfilling their absorptive function, must be so arranged as never to act as splints to the lower limbs; that waterproof drawers should be used only as an emergency precaution; that wool next the skin, far from being necessary, should certainly in warm weather be condemned, linen or woven cotton being then preferable for all infants, and in cold weather also for those whose skin is inclined to become spotty with sudaminal rashes or lichen urticatus; and finally that knitted bootees, stockings, bonnets, and shawls should not be slavishly forced upon an infant at all times as essential to his well-being, but that he should wear each of these garments only when common-sense dictates that without it some part of him would be liable to become cold and uncomfortable. The widespread notion that an infant requires more warm clothing than an adult *in similar circumstances* is physiologically unsound. Over-clothing of infants and young children by day and by night is a very common fault, responsible for much discomfort and consequent fretfulness and restless sleep. The back of the hand should be passed in under the clothing to feel the infant's skin: if this is hot, moist, and clammy, then he has too much on; if it feels comfortably warm, then he has enough on. The hands, feet, and noses of many normal infants (and adults) habitually feel cold to the

*Their
practical
application*

examining hand, but are nevertheless perfectly comfortable to their owner.

(2)—The Management of a Normal Child during Early Infancy

Immediately after birth, the eyes receive prophylactic treatment (usually the instillation of two drops of 1 per cent silver nitrate solution, which is subsequently washed out by a few drops of boric acid lotion); the nostrils, mouth, and pharynx are very gently wiped out to remove liquor amnii and excess of mucus, and if necessary suction is applied to the laryngeal region through a soft rubber tube; the umbilical cord is ligated and severed, and the stump protected by a dry gauze pad; and the infant is then quickly but thoroughly examined for evidence of any abnormality or birth injury, and to make sure that respiration has been normally established and that circulation is normal. He is now warmly wrapped up until his attendant is free to cleanse his skin of its coating of vernix caseosa, either by swabbing with cotton-wool pledgets soaked in warm olive oil or liquid paraffin, or by very gently washing in warm water and a non-irritating soap, subsequently dabbing the skin dry with a warm soft towel, and smearing a little oil over the whole body before dressing the infant. He is then put to sleep in a warm cot in a warm room, and left undisturbed. The care of premature infants is discussed under the title *Care of new-born* **PREMATURITY**.

The skin of a young infant is very delicate, and liable to damage by dirt, infection, friction, and the irritation of chemical agents, such as those occurring in urine and in soap. The entire body surface, including face and scalp, should be cleansed daily from birth by bathing in water at a temperature of 98° to 100° F. at first, the atmospheric temperature in the neighbourhood of the infant being about 70° F.; thermometers are desirable for checking both bath and room temperatures during the early months. As the infant grows older it is as well gradually to accustom him to sudden changes of temperature by sponging or douching him quickly at the end of the bath with fresh water, at first only a few degrees cooler, and in course of time slowly lowering the temperature of this until eventually he is having a cold shower. *Care of the skin*

A non-irritating soap can be used from birth, but friction should be avoided both in applying this and in drying the skin after the bath. If spots, rough areas, intertrigo, or excoriations appear, a muslin bag of fine oatmeal may be soaked in the bath water, and the use of soap omitted temporarily. In the early weeks a bath of physiological saline, without soap, is beneficial for infants whose skin seems especially liable to trauma. *The bath*

The skin should be gently dried by dabbing rather than by rubbing, all folds and crevices being carefully held open until dry. The usual infants' dusting powders (such as talcum, or zinc oxide, starch, and boric acid) are helpful in preventing friction between adjacent surfaces, but they must not be used as a substitute for complete drying of the skin.

*Prevention
of napkin
dermatitis*

To prevent napkin dermatitis, soiled napkins should be removed as soon as possible, the wet area of the skin being dabbed clean with warm water (or olive oil if the skin is especially delicate) and then completely dried. It is wise to allow an infant to spend some time every day lying in a warm atmosphere with its napkin area exposed. Linen, being more absorbent and—when wet—less irritating to the skin than cotton, is preferable as a material for napkins.

*The
umbilicus*

The umbilicus should be kept dry and protected from infection (the bath water not being allowed to touch it) until the cord has separated. Subsequently the wound is dressed with an antiseptic powder such as boric acid and a dry dressing is held in place with a binder until it has healed. It is best to cleanse the wound by swabbing with boric acid lotion, rather than to immerse it in the infant's bath water. A tight binder will not, contrary to popular belief, either prevent or cure an umbilical hernia. When healing is complete the binder becomes unnecessary, and should at once be dispensed with.

The eyes

The eyes, if they appear normal, require no treatment subsequent to the initial instillation of silver nitrate (1 per cent) at the time of delivery. In the early months of life they should be protected from direct strong light, which often appears to distress a young infant.

*The nose
and ears*

The nostrils and external auditory meatuses should not be syringed or vigorously cleansed with the aid of match sticks. The ordinary deposits of atmospheric dirt may be removed with a small twist of cotton-wool, but nasal mucus and aural cerumen, being normal secretions in the infant as well as in the adult, need not be ruthlessly wiped away.

The mouth

The mouth of a toothless infant should be inspected daily to make sure that it is healthy, but if healthy, ought never to be touched. Popular cleansing methods, ranging from the wiping out with a urine-soiled napkin to the more modern swabbing with cotton-wool and antiseptic lotions, are liable to damage the mucosa and predispose to stomatitis. A moderate white furring of the tongue is often seen in normal babies, and does not call for treatment.

*The female
external
genitals*

The female external genitals, if healthy, should be cleansed like the rest of the body surface, simply by gently sponging from front to back, in the bath, the folds of skin being separated during both the washing and the subsequent drying. The direction of drying should similarly be from before backwards.

*The prepuce
and glans*

The prepuce and glans of a male infant should if possible be gently washed and dried daily from birth, the prepuce being fully retracted each time, and subsequently returned to position, after lubrication, if it is tight, with a smear of liquid or soft paraffin. If, at birth, the preputial orifice is of the pinhole type, so small as to render any possibility of retraction out of the question, the best course is probably to perform circumcision within the first week, when the parts are relatively insensitive and an anaesthetic need not be used. If, however, the prepuce is found to be adherent but not in itself narrow and tight, it should be stretched at once, any adhesions being broken down, until

it is fully retracted. After this it can be retracted daily for washing, as described above.

The breasts of an infant very commonly become swollen and hard, usually during the first two weeks of life, and may secrete a little milk. This glandular activity, which apparently results from transfer to the baby, through the placental circulation, of the hormone responsible for initiating mammary function in the mother, may be viewed as a normal phenomenon, and usually subsides within two or three weeks. It is important that nothing whatever should be done to the breasts. The rubbing or squeezing often advocated by midwives and grandmothers of the old school, in common with the procedure of 'breaking the nipple strings' by pulling on the nipples of any new-born baby, are the commonest causes of mastitis neonatorum, which may occasionally develop, rarely leading to abscess formation. It is very uncommon for an infant's breasts, if left untouched, to cause any trouble whatsoever.

The bowels of a new-born infant must never be assaulted by the old-fashioned procedure of 'clearing out' with a dose of castor oil or other purgative. Few or many small daily motions of meconium are normal for the first two or three days, until waste products of digested milk begin to appear, forming the well-known yellow 'pasty' infant's motion. Many infants do not for several months acquire the habit of producing the one or two daily motions which their parents and nurses appear most ardently to desire. It may be stated that a healthy baby, displaying no abnormal symptoms, need not cause any concern whatever by producing anything from four or five motions daily to one motion every two or three days, provided that these motions are of normal consistency and character. Green coloration of such motions, appearing either occasionally or regularly, in the absence of any abnormal symptoms, is also of no special significance. Much unwarranted dosing of infants results from failure to appreciate these facts. Since, however, it is advisable to establish the habit of a daily motion by the time of the commencement of mixed feeding, it is a good plan to begin in the early weeks to train an infant to regular habits, by sitting it upright for a few minutes, fully supported by the outstretched hands and the chest, on a small chamber placed on the lap. If this is done immediately after a feed in the morning and evening as a regular routine, and possibly after the other feeds as well, most infants will soon begin to react to the stimulus of the cold chamber rim on the buttocks, by straining and producing a motion forthwith. This procedure also results, often within a few months, in a considerable degree of control of micturition. Such early training is naturally a great help to the mother or nurse in lessening the number of soiled napkins, and is also of benefit to the infant in establishing voluntary control of the bladder and rectum long before it would otherwise have been acquired.

It is, generally speaking, advisable to keep a normal new-born infant in the more or less constant temperature of a warm, well-ventilated room for a period varying from two days to a week after birth, the

The breasts

The bowels

*Establishment
of regular
bowel habits*

*Adaptation
to changes in
atmospheric
conditions*

Outings

length of time depending upon the apparent vigour of the individual child and upon weather conditions. He must be accustomed to changes in atmospheric temperature and humidity, as to all other changes in his new environment, by a process of gradual training. Therefore the first outing on a winter day should be of only a few minutes' duration, the child being well protected against damp and against cold wind. In this connexion it should be borne in mind that several layers of knitted woollen garments protect the body less against wind than does a single layer of close-woven material. The length of the outing can be gradually extended day by day until the baby is, ideally, having the whole of his day sleeps out of doors, in all weathers except fog, provided that he can be sheltered from the elements. In warm summer weather it is wise to make provision at the earliest moment for an infant to spend as much time as possible, asleep or awake, in the open air, protected, except during short intervals, from the direct rays of the sun. Provided that there are facilities for the child to be in the open air at home, there is absolutely no sense in insisting that he be taken for daily walks in a perambulator along a road or street or in a park, before the age at which he is able to appreciate and benefit from changes of scene and surroundings.

Room temperature

A good average temperature at which to keep the atmosphere of a nursery in the region occupied by an infant is 65° F. When a young infant is undressed the temperature should be nearer 70° F. When he is tucked up in his cot asleep, he should in the early weeks be gradually accustomed to progressively lower temperatures until, in temperate climates, he is sleeping in a room with widely opened windows. Naturally in extreme climates this process must be very much more gradual.

Routine of sunbathing

Direct rays of sunlight are as important to an infant's well-being as is unlimited fresh air. Those in the tropics and those in far northern latitudes are the most likely to suffer from lack of sunshine. A system of sunbathing is strongly recommended for all infants, commencing at the age of three or four weeks by one minute's exposure daily of the whole infant, completely stripped, to the direct rays of the sun, without the intervention of ordinary window glass. In winter this may be done in a warm room near to an open window, preferably at midday. Slowly the length of exposure is increased, at first by a minute every few days, and later, as the child's skin becomes tanned, a little more rapidly, until he is, if possible, spending long periods naked in the sunlight, the head and eyes alone being shaded.

Sleep

In his early weeks a normal infant usually sleeps deeply, and his days and nights should be spent in continuous sleep in a cot, except for the breaks necessary for feeding, bathing, and changing of clothes. By the second or third month of age sleep has become less profound, and the baby is responding to attention. From this time onwards, while still the greater part of his day is spent in sleep, he normally has periods of wakefulness, which vary greatly among individual babies. It is important that he be trained from the beginning to lie contentedly at times by

himself, even though awake, with no one taking any special notice of him. But it is equally important that he should be 'mothered' and nursed at times every day, so that mutual enjoyment may exist between the parents and the child. This ought not to involve tossing the baby about and working him up to shrieks of excitement, but he should be reasonably stimulated and played with, whilst being given freedom to kick and exercise all parts of his body.

The question of an infant's position during sleep is important. He should be firmly swaddled, and laid in the cot on one side, rather than on his back, the right and left sided positions being alternated to ensure that pressure is exerted evenly on the head and body. There may be an advantage in placing him, when put to sleep after a feed, on his right side, especially if he is inclined to have discomfort at this time owing to 'wind'. The writers feel that it is probably advisable to raise an infant's head to a slightly higher level than the trunk, in order to minimize any risk of regurgitated stomach contents gravitating into the Eustachian tubes (which are relatively short and patent during infancy) and predisposing to otitis media. For this purpose it is probably best to tilt the whole mattress slightly; alternatively a firm pillow may be used. It is perhaps not superfluous to mention that a comforter is a bad thing, and that the habit of thumb-sucking during sleep should be checked from the outset by tucking down a baby's arms. *Position during sleep*

Although infant feeding, including the preparation of feeds and care of bottles, is dealt with fully in the appropriate section (see INFANT FEEDING), it is as well to consider here the handling of the baby during and after feeding. An infant at the breast ought to be held on the arm, propped up in a semi-sitting position, and facing inwards towards the mother's nipple, rather than lying flat and receiving the nipple from above. Similarly during artificial feeding, whether by bottle or by spoon, a semi-sitting or full sitting position, adequately supported, is to be recommended. In this position the tendency of swallowed air to accumulate in the stomach is minimized. It is a thoroughly bad practice to feed an infant lying flat in its cot, whether the bottle be propped on a pillow or whether it be held by hand. Air is normally swallowed in greater or less amount during sucking; the infant normally regurgitates this air, and should always be helped to do so by being held up against the shoulder with the whole body upright for some minutes after feeding, and possibly also once or twice during the feed if he is inclined to suck noisily and greedily. He will then 'break the wind' in small quantities, probably without regurgitating any milk. If he is put straight down to sleep after a feed, without being first held up in this way, there is apt to be discomfort from 'wind' retained in the stomach, and this, when regurgitated, is likely to bring with it some of the stomach contents. Although it is at times useful to sit an infant upright and give him a teaspoonful or two of warm water in order to help him to regurgitate air from the stomach, we must condemn strongly the very common practice of giving a bottle of water *Handling during feeding*

as a matter of course between feeds, or whenever an infant cries. This may appear to soothe him for the moment, but it is inadvisable, since the stomach is liable to become distended as a result, with consequent risk of discomfort and vomiting.

*Discipline
and training*

From almost the moment of birth a baby is amenable to training in habits, good and bad, and it is much easier to form the good habits than to break the bad. Hence the great importance of consistent training from the beginning in regularity as regards feeding (the infant being wakened if asleep when a feed becomes due, and similarly being made to wait even if he cries before the proper time), and as regards sleeping, bathing, and any other activities that go to make up the infant's day. Hence the importance also of disciplinary matters such as withholding a feed in the middle of the night, and of withstanding the temptation to pick a child up the moment he cries, whether he requires attention or not. If attention is required, it must of course be given, the infant then being put back in comfort in his cot. Sensible training of this kind, which often requires great strength of mind on the part of parents and nurse, bears its own reward to the parents when they can report that 'you wouldn't know there was a baby in the house'.

(3)—Management during Late Infancy and Childhood

Between nine and twelve months of age a child normally becomes a mobile individual, capable of understanding and of volition. Those responsible for his care from now onwards should base their methods of handling and training upon a realization that he is a primitive young animal, energetic, highly suggestible and imitative, but only moderately rational, with a strong tendency to habit formation.

*Learning to
walk*

Learning to crawl, to stand, and to walk should be left to the child himself. No effort must be made either to encourage him unduly or to check his voluntary efforts, since a normal child will naturally attain these accomplishments whenever his limbs are strong enough. A large play-pen placed on the floor, or on the ground out of doors whenever possible, fitted preferably with a firm waterproof mattress or ground sheet, is of great value in giving the baby a place in which he can exercise and tumble about unrestrictedly.

*Play and
companionship*

Play is the normal activity of children, and it should be guided, restricted, or interfered with by adults as little as possible. Companionship with others of similar age is of great importance in helping a child, at every age, to derive from play the maximum benefit as regards both character training and exercise. For an only child especial efforts must be made to obtain this companionship; kindergartens and nursery schools are of great value in this respect.

Sleep

Exercise is normally taken by an infant in kicking, crying, wriggling, the crawling, and by an older child in the course of playing. There are, particularly on the Continent, some who advocate giving exercises that have a gymnastic nature even to normal infants and young children.

Needless to say the more exercise that can be taken out of doors the better. As far as possible it should be a part of the spontaneous play of children, rather than in the form of set walks under adult control. Later, during school years, organized games are a valuable factor in the training of character and body, but there is still a need for ordinary free play. It is important that this should not be forgotten by those in charge of schools and other institutions.

Rest and sleep are of supreme importance to a growing child. Over-fatigue and lack of sleep rank with improper diet as main factors in the causation of malnutrition among poor children. Again and again a child, brought for advice because he is 'not getting on', is found, only on detailed questioning, to be going to bed at 8 or 9 or 10 o'clock, rising at 7.30 in the morning, and having no rest during the day. If the parents can be persuaded to work his bed-time forward to 6.30 or 7 o'clock, and to institute a short midday rest, one repeatedly finds such a child within a few weeks to be apparently improved in health, and gaining weight satisfactorily.

*Rest and
sleep*

At the age of a year most infants, if properly managed, will sleep for twelve hours by night, and three or four hours (in two periods, morning and afternoon) by day. A single day sleep should be continued if possible up to the fifth year, or later, and when a young child will no longer sleep by day it is well for him still to lie down for a short midday rest, unless this should prove really irksome. During the early years 6 o'clock is a good bed-time, and until about the age of eight a child should be up not later than 7 o'clock at night, so that he can have approximately twelve hours' sleep. During adolescence he should still sleep for between nine and ten hours every night. These may be considered as general rules, but it must be realized that from infancy throughout life there is a wide variation among individuals with regard to both their capacity and their need for sleep.

Mismanagement is the most frequent cause of bad sleeping habits developing in later infancy and childhood. If from the outset a baby has been trained to go to sleep in his cot of his own accord regularly at the proper times, without the ordinary noises of a household being unduly silenced on his behalf, and if, as he grows older and more intelligent, this habit is in no way altered, then there need be no trouble. Provided he is well and does not require attention, sleeplessness should be ignored. If he is restless, provision should be made, as by the use of a sleeping bag, for restraining his movements and for preventing chilling during the night as a result of the throwing off of bed-clothes. Moderate restraint by means of swaddling, as in early infancy, often aids sleep, provided that the child is not thereby overheated. Proper room ventilation is essential, and a separate bed should, whenever possible, be provided for each child. Especially for excitable children it is important to ensure before bed-time a period of quietude. This can, with the help of stories, picture books, and toys of not too exciting a nature, be made a very happy time, which culminates in the actual

*Bad sleeping
habits—
prevention
and treatment*

going to sleep; thus the pleasant associations of bed-time are made to outweigh in importance the child's inevitable disinclination to cease the day's activities and go to bed.

Clothing

Clothing has already been discussed in general terms. When a baby begins to crawl he should, during cold weather, be dressed in some form of 'crawlers' made of strong washable material, which will help to keep the legs and thighs warm when he is on draughty floors, and still allow complete freedom of movement. In hot weather the less he has on his body and limbs the better. Many parents seem to have an unjustified fear of children 'catching cold' as a result of walking bare-footed on the floor or ground. Shoes must be chosen with care to fit easily upon the foot in its natural form during standing, while not being large enough to slip about. There is no need for special shoes with 'arch supporters', which certain manufacturers are inclined to boost: flat foot and other deformities must be medically treated, while a normal foot should be given the maximum of freedom (with the help of running bare-footed whenever possible) to enable it to support its own arches. In wet weather waterproof coats, leggings, and overshoes are naturally to be recommended, but if clothes or shoes do become damp, no harm need be feared provided that the child is not allowed to sit about and become cold in them. Following strenuous exercise, as, for example, football, which demands a minimum of clothing, warm clothes such as sweaters should at once be put on, in order to prevent chill consequent upon the rapid evaporation of sweat.

*Management
of feeding*

The management of feeding is a question which causes much trouble, bringing innumerable healthy children to the doctor with the complaint that 'he won't eat'. In this, as in so many other aspects of child management, the early inculcation of proper habits, which are maintained and enforced with moderate and kindly firmness but without fussing, is of the greatest importance. An infant who has been accustomed from the first to take water, orange juice, and the like from a spoon, is unlikely to object to taking solid foods by spoon when these are commenced at about the seventh month. In the same way, a gradual process of training to drink some fluid daily from a small cup, commenced at five or six months of age, will obviate later difficulties when it is time to substitute a cup for the breast or the feeding-bottle at about the ninth month. If such early training has been neglected, and if the infant persistently refuses to take from a spoon at the time when its use becomes desirable, a good way of handling the situation is to pinion him in a towel at feeding-time, hold him firmly, sitting on the knee with his head fixed by the left arm, insert a small spoonful of food into his mouth, and then hold his lips shut until this is swallowed; then to repeat this process with one or two spoonfuls only, not going on long enough for either the baby or his mother to become distressed by the fight. He should then be calmly given the remainder of his meal in the manner to which he is accustomed. As time goes on resistance will be found to diminish, and at last he will come to eat voluntarily from a

spoon. For a baby who refuses to take fluids except from a bottle (at nine or ten months of age) the proper treatment is to put the bottle away for good, allowing the infant to drink from a cup or not at all. A few days of underfeeding cannot hurt any healthy child, and before long the desire for food and drink will persuade him to use a cup. Throughout this training process the mother must make every effort to remain calm and unconcerned. Once the breast or bottle has been discontinued it is a great mistake to revert to it in the event of illness, fretfulness, or other cause of difficulty in feeding.

The management of weaning is discussed in the article on INFANT FEEDING.

At all ages children are liable to develop fads about their food. These are only encouraged by undue talk about nice and nasty foodstuffs, and by discussion regarding likes and dislikes. The proper procedure is for a mother, having acquired the requisite knowledge of how to constitute a child's diet, to plan his daily meals on a basis of this knowledge, rather than on a basis of what he says he would like, making the meals as varied and as attractive as possible, and tactfully including only small quantities of any necessary article which he is known not to enjoy. The meals are then placed before the child, under the assumption that he will eat the whole of what he is given. If his appetite is small, then he must in fairness be given very small helpings: he can always ask for and be given a second helping, this being an encouragement to both him and his mother. If he will not finish a reasonably small helping in a reasonable time, what is left should be unconcernedly cleared away, without nagging, coaxing, or scolding. The secret of 'making a child eat' is to make not the slightest effort to do so. His appetite and feeding habits should never be discussed in front of him, and it is most important that no particular interest or anxiety should be manifested. The 'only child' is especially prone to feeding difficulties, on account of his knowledge of the concentration of parental interest upon himself. Such a child, when placed among others and away from his parents, will usually begin to eat heartily within a short time, as a result of force of example and freedom from undue attention.

A young child, though usually eager to be independent and to feed himself, is apt to find the actual process of wielding a spoon both tiring and boring. He should be helped by being given a small spoon, which is also useful in discouraging habits of 'bolting' food, and a special baby's plate, and by being tactfully fed whenever he shows signs of tiring. Adults must, however, remember that a child's appetite is as good a guide to his food requirements as is their own, and must not indulge in the folly of trying to make him eat when he says he has had enough. A strict rule should be made, and kept, that nothing is to be eaten between meal-times. If then a child commits an error of judgment in refusing to eat one meal, he must bear the consequences by feeling unduly hungry before the next meal-time, and thus he learns

Feeding difficulties

Acquisition of good feeding habits

from experience. Another rule should be that he sits quietly throughout the meal-time, whether eating or not. This discourages any tendency to refuse to eat simply for the purpose of returning quickly to play. A rule for adults is that they must not give children tastes of unsuitable and forbidden foods, which only vitiate the appetite and make for discontent with ordinary wholesome foodstuffs: these, if intelligently prepared and served, need never be dull or monotonous.

During school years it is important so to plan the day that a child can eat his meals unhurriedly, and if possible sit quietly for a few minutes afterwards without fear of being late for school. In any event strenuous exercise should never be taken immediately after a meal.

*Sphincter
control*

Control of the bladder and bowels is generally acquired without difficulty by a normal child at the proper time, if the early training methods already mentioned are sensibly employed. It is wrong, however, to push these methods to the extreme stage at which any failure to use a chamber, followed by subsequent accidental soiling of clothes, is treated as a serious offence. There is an unfortunate tendency among some 'intelligent' mothers and nurses to make a baby a slave to the chamber pot, with the common result that sooner or later he rebels and comes to dislike the thing, refusing to go near it. Because small children have normally less control of their excreta than adults, occasional accidents are inevitable, and these should be dealt with in a spirit of sympathy as well as disapprobation.

*Position at
stool*

When he is old enough to sit alone on a chamber, it is best to give a baby a small arm-chair with a hole in the seat, under which the chamber fits. On this he can sit comfortably and securely, without fear of tipping over. The seat should be of a height to allow him to occupy a semi-squatting position, with knees raised and heels set firmly on the floor; this position aids defaecation. When a small child comes to use an ordinary water-closet, it is a good plan to provide for him a special removable seat with an opening of suitable size, and a firm stool on which to brace the feet, so that he can still take up this position, rather than one of precariously balancing on the edge of a frighteningly large opening, with legs dangling.

*Training in
regularity*

Habit plays a large part in the functions of micturition and defaecation, and early training to regularity in these matters, maintained as age advances, is very important. Even if there is no desire to defaecate an attempt to do so should be made as a matter of course at the same time every day, preferably soon after breakfast. It is quite unnecessary to insist that a child should try to pass a motion after every meal; such a habit is only likely to be a nuisance to its victim in adult life. He must, however, be encouraged to stop whatever he is doing and attend at once to the desire for defaecation, and every allowance should be made for him, in school and elsewhere, in this respect. The same applies to his desire for micturition. He should always be given enough time after meals to attend to these functions without undue hurry. Failure to arrange breakfast sufficiently early to allow for this before leaving

for school results in bad habits which are probably responsible for much of the constipation occurring amongst school children. The deeply rooted custom of giving a weekly dose of purgative to healthy children with normal bowel function should be whole-heartedly condemned by the medical profession, for its only result is to upset periodically a normal activity of the body.

Constipation and other abnormalities are dealt with in the appropriate sections.

Habits of personal cleanliness are generally acquired fairly easily by normal children, provided that they are properly trained from early days, and provided that the rest of the household sets a good example. The majority of small children appear to have a natural tendency to be dirty, and the aim of training should be to teach them to distinguish dirtiness from dirtiness that does not; to teach them, for example, to wash after visits to the water-closet and after handling animals, while still allowing them to get dirty in suitable clothing during play. Proper nursery routine in regard to washing, bathing, cleaning of teeth, and general tidiness, established early and continued as an ordinary part of the day's activities, will suffice to train most normal children in these matters. *Personal cleanliness*

Talking is a sign of a child's mental development which, if apparently abnormal, may cause great anxiety to parents. Young children simplify language into 'baby talk', but if adults do the same thing, then they retard the child's natural tendency to acquire ordinary speech, and are apt to cause him embarrassment later, when he becomes self-conscious about his own particular language. A child will usually learn to talk more readily from older children than from adults. Speech defects are discussed in the article under that title. *Talking*

(4)—General Principles in Management and Training

Although questions of behaviour and the reactions of childhood, and their influence upon later life, are rightly held to form part of the psychologist's province, the paediatrician and the family doctor, by virtue of their wide experience of children both normal and abnormal, acquire a breadth of knowledge which puts them in a peculiarly advantageous position for assessing standards of normality, and offering guidance in problems of management to parents and others responsible for the care of children.

Heredity undoubtedly plays a large part in determining a child's character, but the surest provision for good character training is the environment of a happy, well-conducted home. A child learns very largely by imitation of those about him; their manners and deportment, moral standards, and emotional reactions are likely to be reflected in his behaviour. Thus truthfulness, honesty, courage, and unselfishness are imparted by example rather than by precept. He is impressionable and sensitive to 'atmosphere', and whilst too young to understand it can yet appreciate and benefit from an atmosphere *Home influences*

of love and sympathy, just as he can suffer from surrounding discord and unhappiness. Bad impressions received during the first year or two, and bad habits then formed, seem, however, to be not necessarily permanent, a later change to a good environment going a long way towards obliterating them; after the age of four or five years, however, impressions, good or bad, become more deep seated, and habits become increasingly difficult to alter.

Discipline

Discipline, being essential to well-ordered community life, should in fairness to children be exerted from the outset. The worst sufferers from the doctrine that children should be allowed complete freedom of expression, untrammelled by discipline, are the children themselves. They are likely to be unpopular during childhood, and sooner or later they have to learn, what then proves the harsh lesson, that they must submit to discipline and conform with the rules of community life. Discipline should be exerted with kindly understanding, not in a spirit of 'spare the rod and spoil the child'. Since a child is very sensitive to injustice, it is most important that his elders should be strictly fair in all dealings with him; that they should try to appreciate his point of view; that, while insisting on obedience, they should, whenever possible, make clear to him the reason for commands and prohibitions, and avoid unnecessarily changing their minds and reversing their decisions; and that they should make generous allowance for his shortcomings. Punishment should be given only for real transgressions; any punishments threatened should be carried out if necessary, but calmly and not in anger, the child being made fully aware of the reasons. Corporal punishment is justifiable only in exceptional circumstances. An example of wrong punishment wrongly given is the vicious slapping of a child by a mother exasperated by his fidgeting or 'touching' or asking innumerable questions—all normal activities of a normal child. It is surely better for that mother to divert the child's interest to some other occupation or play, whilst making an effort to take her own attention away from him.

*Leaving
children to
themselves*

Since an adult is unlikely to be able to remain in continuous close association with small children without being acutely irritated at times, it is important for a child to have periods of complete freedom from adult supervision, preferably in the company of other children, although a certain amount of solitude is undoubtedly of great value in teaching him to rely on his own resources for amusement and occupation. The point must be stressed, that children should be left alone to arrange their own play and other activities. Nowadays nurses and parents are too much inclined to manage the whole of a child's waking hours, playing with him, doing things for him, and generally keeping him company, so that he has little opportunity for learning to depend upon himself. There is wisdom in the saying that 'Satan finds some mischief still for idle hands to do', and for his happiness and usefulness both present and future a child should be encouraged to do things for himself, to look after his own possessions, and whenever possible

to help with household activities, which serve to interest him and make him feel that he has a part to play in relation to the other members of the family.

All active teaching of children should be performed as far as possible in a spirit of co-operation, rather than by imposing the will of the stronger individual upon that of the weaker. A child is in a weak position relative to adults, and they must appreciate the fact that some rebellion on his part is therefore almost inevitable. If they imagine themselves in his position, they will understand such demonstrations as outbursts of temper on slight provocation, refusal to eat, and manifestations of behaviour which may be interpreted as mere perverseness, by means of which the child attempts to focus interest upon himself and to create a scene which he believes will end in his victory. If such disturbances are treated with unconcern, combined with sufficient firmness to prevent the child from achieving victory by these means, he will usually realize that they are fruitless, and give them up.

*Co-operation
between
adults and
children*

Because of their imperfect understanding, children are apt to find many of the ordinary things that happen around them intensely worrying. Here again grown-ups must try to see the child's point of view, and to inspire in him a degree of confidence which will make him feel secure in spite of inevitable doubts and anxieties. They must be calm and straightforward in all matters, and must avoid meaningless threats and promises which serve to destroy a child's confidence and respect. It may seem superfluous to condemn such threats as to 'give you to the policeman', or 'take you to the doctor', or 'go away and leave you', but the practitioner must be prepared to deal with parents who frighten their children in such ways. Those responsible for the handling of children must realize the importance of great patience, cheerful good temper, and a placid outlook. Short-tempered, over-anxious, or fussy persons are, in fact, entirely unsuitable for managing children satisfactorily.

For success and happiness throughout life, a child should learn early to adjust himself to herd existence. An only child must therefore be given every opportunity of mixing with other children. An 'ex-baby', who may be resentful at having apparently to take second place, should be helped to adjust himself by being tactfully guided into accepting some duties, such as helping regularly with the new baby's bath, which will make him feel that he is an important part of the household.

*Adjustment
to community
life*

School life, especially at a boarding school, is invaluable in helping a child, particularly one who has been much in the company of adults, to find his own level among his contemporaries, while submitting to discipline the more easily because of the example of others. During this period sensible and understanding supervision should be exercised, both at school and at home, on the one hand to prevent the dull child from suffering as a result of his inability to do as well as his contemporaries at lessons or games, and on the other hand to prevent

School life

the bright and active child from over-fatiguing himself either mentally or physically. In this period of life adequate rest and relaxation are all-important (see CHILD GUIDANCE, p. 125).

Sex education The problems of sex education should be dealt with by answering early questions truthfully in language which can be understood, supplementing this as time goes on by any further explanations stated in the simplest possible terms. A child who is put off with fantastic stories about where babies come from will realize sooner or later that he has been deceived, and will come to feel that there must be some mystery which those who told him such stories are unlikely to elucidate truthfully. If naturally inquisitive, he will try to find out for himself and will perhaps acquire some garbled account of things from his contemporaries, in an atmosphere of unwholesome secrecy; if not, he may remain in ignorance until 'the facts of life' are brought home to him during adolescence, possibly in such a way as to cause him mental and emotional disturbance. Sex education should come best from parents, whose duty it is to see that their children face adult life with a sane and wholesome outlook on these matters. During adolescence the inevitable problems that arise must be faced with understanding and common-sense, the child being guided rather than driven or led through this often difficult period of life.

3.—THE PROMOTION OF CHILD HEALTH

234.] Having dealt with normal growth and development, and with the principles of the management of normal children, it is appropriate now to consider briefly the salient features of the State scheme of Maternity and Child Welfare at present operative in England, which has as its aim the prevention of infantile mortality, the promotion of infant and child health, and the maintenance of well children in a condition of such health as ultimately to produce an A1 adult population. This work is essentially prophylactic, and as such it must be regarded as a branch of preventive medicine equal in importance to any other section of public health work in its broadest sense.

It is advisable that practitioners in England should be familiar with the details of this scheme, in order that they may make use, on their patients' behalf, of the facilities available. In a wider field also it may prove useful as an example on which schemes relating to child welfare elsewhere can be based, whether in connexion with individuals or in connexion with larger groups of the community, such as those occurring in institutions and schools.

The essential part which the medical man has to play in matters of child health and hygiene is to-day being emphasized by the insistence of certain university authorities on attention being given to these subjects in the teaching of medical students. These authorities require that the student should attend at recognized infant welfare centres before he proceeds to medical graduation. Moreover, in order to afford

some special qualification for those engaged in child welfare work, the Royal Colleges of Physicians and Surgeons in England have recently introduced a Diploma in Child Health, and since 1928 the Society of Apothecaries has granted the Diploma of Master of Midwifery, designed primarily for those who propose centering their attention upon maternity and child welfare work. Half of the examination for the latter diploma is devoted to the subject of infants and young children.

The State scheme in England is under the control of the Ministry of Health, but the duty of carrying it out devolves upon the local authorities of urban or rural districts. It is financed partly by grants from the Ministry of Health, and partly from the rates. The details vary considerably in the hands of different local authorities, and naturally in some districts greater facilities exist than in others, but the general scheme recommended by the State for the welfare of the child in this country includes the services which will now be mentioned. It should be stated here that many voluntary associations co-operate with local authorities in carrying out this work. The Statutes and Acts of Parliament relating to this scheme, and the details involved, may be found in the official publications governing the subject.

The opening scene in this work is laid in the antenatal period. Special *Antenatal clinics* are provided for antenatal consultation and supervision; here routine examinations of the expectant mother are made by a medical practitioner having special knowledge of the subject, advice is given, and educational talks and demonstrations are often arranged. Where specialist consultations or further investigations—such, for instance, as radiological, pathological, or bacteriological examinations—are required, or where any form of out-patient or in-patient hospital treatment, medical or dental, is needed for during the antenatal period, arrangements are made by the ^{local} authority for these to be available. It is also empowered to provide, when necessary, surgical appliances and dentures free of charge. In cases of necessity, allowances of milk or of free dinners, and such prophylactic medication as appears from a physiological standpoint to be indicated, may be given to expectant mothers for a period leading up to full term, on the recommendation of a medical officer of the local health department. The importance of this work lies, of course, in ensuring so far as is possible that the pregnant woman is maintained in the optimum condition of health, and that eventually her delivery is a normal one, with the least possible amount of manipulation, and the best possible chance of obtaining a normal healthy infant.

Next comes the provision made for the expectant mother at the time of parturition. She may be given help, at the hands of the antenatal clinic, in arranging for suitable hospital bed accommodation, with transport facilities from her home. For confinements in the home there are various ways in which the service of midwives is made available, and the assistance of doctors or consultant obstetricians may be arranged for. A practitioner can, in fact, by applying to the health *Provision for confinement and puerperium*

department of the local authority in many districts, arrange for a consultant to see a necessitous private patient at any time during her pregnancy, confinement, or puerperium, a fee being paid to the consultant by the local authority. In addition, by application to this authority he is able, for the confinement, to obtain a sterilized outfit of maternity dressings, which is paid for by the authority if the patient is unable to meet the cost. Finally in this connexion the provision of 'home helps' must be referred to, as a measure which proves of great assistance to families in poor circumstances. The 'home help' is a woman paid by the local authority in necessitous cases to go in and look after the home and children while the mother herself is confined to bed, either during the lying-in period, or at other times when she may be ill, if she has children under the age of five years.

Postnatal clinics

Postnatal clinics also exist for the purpose of supervising the health of the mother in the period following her confinement, and thereby fulfil most useful work. Many authorities have facilities available for sending women to convalescent homes at this stage, and even during the prenatal period also if necessary.

Contraception

It should be mentioned here that local authorities are empowered by the Ministry of Health to provide properly equipped clinics at which instruction can be given in methods of contraception to married women in the interests of whose health this is considered desirable.

Attention to the newly-born

We must now turn to a consideration of the infant himself. When the birth is notified to the local authority, as is required by law within thirty-six hours, the notification comes into the hands of the local Health Authorities, who are then in a position to make arrangements for a health visitor to visit the mother in her own home, at the expiry of the ten days during which the midwife is held responsible for her and her infant, or alternatively when she returns home from the lying-in hospital. At this visit the health visitor discusses with the mother any questions arising about the health and well-being of herself and the infant, gives any advice or recommends any treatment that may seem to be required, advises the mother to bring the infant, even if no difficulties should arise, to the clinic at the local welfare centre, and generally tries to establish her position as one to whom the mother may turn in search of friendly interest and advice.

Organization of welfare centres

At the welfare centre itself the clinic is conducted by the same health visitor and her assistants, and here a doctor attends in a consultative capacity, in order to examine the children and give advice. The doctor in charge of the clinic is directly responsible to the Medical Officer of Health of the district, and should have some special knowledge of infants and children. The health visitor is equally important. This fact is recognized by the State in its present requirement that she should be a State registered nurse, holding also a qualification in midwifery, who has received a further course of special instruction and passed an examination for her Health Visitor's Certificate. The efficiency of the child welfare work in any district rests largely on the shoulders of its

health visitors. One of their most important duties is to visit the homes periodically, and by their advice to educate the parents in matters of health. At each session of the welfare clinic the health visitor sees all children who come, whilst the doctor is able to see only a proportion of these, and the health visitor must decide in each case whether or not progress is satisfactory, and whether or not it is necessary for the child to be referred to and seen by the doctor. It is his duty to examine the child and give detailed advice in regard to feeding and management. When a consulting opinion or medical treatment is required, he must advise and make suitable arrangements for this to be obtained. Different local authorities have different arrangements with hospitals, dental clinics, treatment centres, and district nursing associations, for the benefit of those unable to pay private medical fees, but when possible it is held to be the aim of the officers of a welfare centre to refer the children who require medical treatment to the care of their own general practitioners.

*Further
activities
of local
authorities*

Many welfare centres include clinics for massage and physical exercises, and also artificial sunlight clinics, where treatment is given to mothers and children requiring it. Some also conduct a so-called breast-feeding clinic. Here a nursing mother may attend, receiving instruction and advice from a nurse who has experience in these matters, in the technique of breast feeding and the management of the nursing; if necessary a series of test feeds can be carried out in the clinic.

Certain local authorities maintain a few cots, to which infants and young children suffering from nutritional disorders may be admitted for observation and care. In addition, there are crèches and nursery schools, for the accommodation and care of young children whose mothers must work away from home during the day. Arrangements also exist by which children can be sent to convalescent homes. Authorities are further empowered to provide clinics staffed by specialists for dealing with children of pre-school age who exhibit psychological problems.

For necessitous cases with a family income below a certain level, the local authority has power to provide, on the doctor's recommendation, milk free, or at reduced cost, for the child or the nursing mother. Some authorities make arrangements for the provision of a daily dinner in a dining centre as an alternative to the milk allowance for children of pre-school age as well as for expectant and nursing mothers.

Another important aim in the welfare centre is to give to parents simple educational talks and demonstrations, on such subjects as personal and domestic hygiene, the planning and cooking of meals, and problems connected with clothing and furnishing.

A fact which should be made obvious by the above account of the work, but which requires emphasis, is that the function of a welfare centre is not the treatment of sick children, for which they really have no facilities. The aim of the Maternity and Child Welfare scheme is

*Aim of
maternity
and child
welfare
scheme*

that these centres should help to keep well children well, by means of advice regarding feeding and all questions of management, directed towards promoting optimum health and nutrition in every child; and in the event of sickness occurring that they should refer such children to their own medical practitioners or to a suitable institution. Far from running in competition with the general practitioner, it is intended that they should constitute a specialized service complementary to his work. The provision of cod-liver oil, iron, and other medicaments ordered for the purpose of preventing deficiency diseases must be looked on as a measure of preventive rather than of curative medicine.

*School
Medical
Service*

At the age of five years the child comes under the supervision of the School Medical Service, where he remains until the school leaving age. A series of examinations are carried out at fixed times during his school career by the School Medical Officers, in the course of which any physical defect, or anything suggestive of disease, such as unhealthy tonsils and adenoids, is detected, and appropriate arrangements are made for consultation at local hospitals, and if necessary for observation and treatment, facilities being provided to ensure co-operation between the hospital and the officers of the School Medical Service. Children who are found to have physical defects receive extra examinations. Treatment centres for dealing with minor ailments exist in connexion with the School Medical Service. Periodic dental inspections are also made, and facilities exist for specialist dental consultations and treatment, not infrequently in conjunction with the special departments of a suitable hospital. Within the School Medical Service there exist arrangements for dealing with physically and mentally defective children at special schools designed for their needs, including open-air schools for those suffering from such conditions as chronic respiratory disease. In addition there are rheumatic supervisory centres for keeping in touch with children who suffer or have suffered from rheumatism and rheumatic carditis, and special hospitals and clinics dealing more particularly with chronic diseases of an orthopaedic nature, or with such conditions as rheumatic valvular disease of the heart. For cases requiring a period at a convalescent home subsequent to illness facilities exist whereby arrangements can usually be made to obtain this. In addition there are in certain areas clinics for the treatment of speech defects, clinics for the treatment of squints, resident schools for the blind, and day schools for myopic children.

For uneducable children there are occupational centres. Grossly mentally defective children can be certified and cared for in suitable institutions, and for epileptics special colonies exist.

*Control of
tuberculosis
and
infectious
diseases*

Apart from the services already alluded to, schemes exist for the control of tuberculosis and for the prevention of infectious disease in children. Both of these aspects of the question are matters of public health, for which the Medical Officer of Health is responsible to the Health Committee of his district. In regard to tuberculosis, there are

special schools for tuberculous children, apart from the ordinary open-air schools. Further, the London County Council has for some years made provision for the separation of the infant from a tuberculous mother, their scheme being based on similar lines to the Grancher system in France, though on a much smaller scale. In connexion with prevention of infectious diseases, the whole question of immunization against some of the common preventable diseases has to be considered. In addition to vaccination against smallpox, immunization of children against diphtheria is now being practised on a large scale in many districts, clinics for diphtheria immunization being conducted in association with the school medical service or the child welfare organization for children of the pre-school age.

With a view to improving nutrition, milk may be supplied at school, either at greatly reduced price, or, for necessitous children, free on the recommendation of a School Medical Officer, in order to improve the child's general nutrition, while cod-liver oil may also be supplied on medical recommendation. In certain schools dining centres are organized. *Improvement of nutrition*

Because of the recognition of the part played by physical education in improving general health, school authorities are empowered to establish properly organized physical training centres. These are already operating in certain districts.

The importance of psychological problems during childhood and adolescence is being increasingly recognized, and for those children who are not in a position to be handled privately by a psychiatrist or medical psychologist, child guidance clinics are now in existence in certain areas. These work in co-operation with the medical services, and are of great value in dealing with children suffering from psychological disorders (see CHILD GUIDANCE, p. 125). *Child guidance*

Notwithstanding the organization of public schemes for the promotion of child welfare, the health of the child still depends in the last analysis upon the care and supervision exercised on his behalf by the general medical practitioner. It is, therefore, of great importance that the family doctor should interest himself in the subject of development during childhood, and should be prepared to give proper advice to the community on all matters connected with the care and management of children.

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CHIMNEY-SWEEPS' CANCER

See CANCER, Vol. II, p. 739; SCROTUM DISEASES; and SKIN:
OCCUPATIONAL DISEASES

CHLOASMA UTERINUM

See BRONZING OF THE SKIN, Vol. II, p. 716; and PREGNANCY

CHLOROMA

See LEUKAEMIA

CHLOROSIS

See ANAEMIA, Vol. I, p. 450

CHOLANGITIS CHOLECYSTITIS CHOLELITHIASIS

See GALL-BLADDER AND BILE-DUCTS

CHOLERA

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1.-EPIDEMIOLOGY

235.] According to John Macpherson's *Annals of Cholera from the Earliest Periods to the Year 1817*, outbreaks that may well have been cholera were described by Sanskrit writers and by Hippocrates about 400 B.C.; he also referred to sixty-six occurrences of the disease in India between 1503 and 1817, a few of which appear to have spread to Europe. The first epidemic of which accurate records are available originated in Lower Bengal in the latter half of 1817, and after the usual winter lull spread all over India during 1818 in probably the most terrible known epidemic. Descriptions of this and subsequent epidemics will be found in N. C. Macnamara's *History of Cholera*.

*World-wide
pandemics
of cholera*

The most frequent route for the spread of cholera from India to Europe is overland from north-west India through Afghanistan and Persia to south-east Russia and the rest of Europe. In the absence of railways the first pandemic of the nineteenth century took the five years 1826-30 to spread from Bengal by this route to south-east Europe, and it reached western Europe and America in the following year. An epidemic that broke out at the Hardwar Kumbh Pilgrim Fair in April 1867 spread to Europe by this route by 1869, but the

epidemic of April 1892 with the same origin reached Europe in a similar manner by the following July owing to improved railway and other means of communication, i.e. in five months instead of five years, as in the first pandemic. Fortunately by this time bacteriology and knowledge of hygiene enabled the outbreak in Europe to be controlled with far less loss of life than formerly. Other routes of spread of cholera from India to Europe are illustrated by the 1848-53 pandemic carried from Bombay via the Persian Gulf, during which John Simon first introduced inspection of ships' passengers instead of quarantine. The 1863-9 pandemic was carried by sea from Bombay to Aden, Mecca, and Egypt, to reach south-east Europe, and the 1879-83 one spread by the same route to Egypt, where Robert Koch discovered the cholera vibrio in 1883. The most fatal of these pandemics appears to have been that of 1840-49, which reached Europe by the overland route and is believed to have killed one million people in Russia in 1847-9, and 53,293 in England; during this pandemic Snow and Budd advocated the now generally accepted theory of water-borne infection against the air-borne theory supported by Baly and Gull, and by J. L. Bryden in 1869 in India on epidemiological grounds with only limited data from army and jail to guide him.

In 1869 Bryden described the spread of cholera epidemics during 1854 to 1868 over northern and central India, and W. R. Cornish soon after dealt with those of southern India for a similar period, but he opposed the air-borne theory. Bryden described and illustrated a large endemic area of the disease, including Assam, Lower Bengal, and eastern Bihar, in which the disease was prevalent every year, and from which it spread, in epidemic form, in certain years to the north-west through the United Provinces and the Punjab and in other years through the Central Provinces to the Bombay Presidency, and Cornish traced their further spread over the Madras Presidency; both authorities held that all the great cholera epidemics originated in Bengal as that of 1817 had clearly done.

Epidemic spread of cholera in India

The view that cholera epidemics all arise in Bengal and spread thence over India was held until a recent comprehensive review by the writer (1926 and 1928) of some sixty years' accumulated vital statistics threw new light on the subject. The present position may be briefly summarized as it has a practical bearing on prophylaxis.

The seasonal incidence of cholera in any given area is remarkably constant from year to year, yet differs widely in the different provinces. The explanation of this was found by a study of the monthly average readings of the absolute humidity or aqueous vapour tension. This term is applied to the actual amount of vapour in the atmosphere measured by its pressure in inches of mercury, and it is essentially a measure of combined moisture and temperature, for low absolute humidities depend on low temperature combined with low moisture and vice versa. In the case of cholera prevalence the critical point is 0.400 inches of mercury, for it was found that cholera is never widespread if the reading is below that level. In Fig. 14 the 0.400 line for January, the lowest monthly absolute

Seasonal incidence and climatic conditions

humidity of the year, is entered, and the average cholera incidence during the three coldest months of December to February is shown by shading

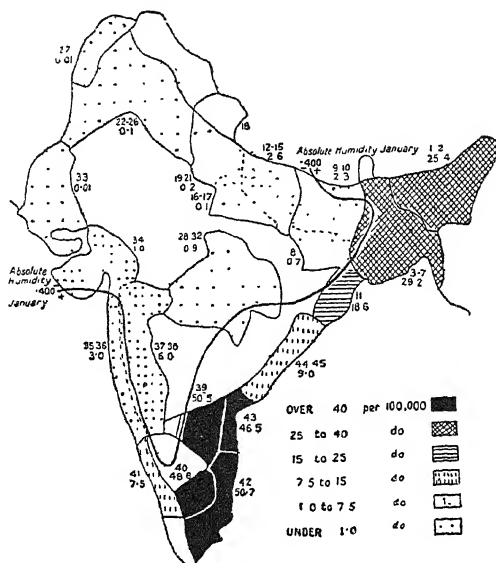


FIG. 14.—Average monthly cholera per 100,000, December-February. 1-2, Assam. 3-7, Lower Bengal. 8-11, Bihar and Orissa. 12-21, United Provinces. 22-26, Punjab. 27, N.W. Frontier Province. 28-32, Central Provinces. 33-34, Sind and Gujerat. 35-36, Bombay Coast. 37-38, Bombay Deccan. 39-40, Central Madras. 41, Malabar Coast. 42-45, East Coast, Madras

(This, and the following 3 maps, from *Proceedings of the Royal Society of Medicine*, 1926)

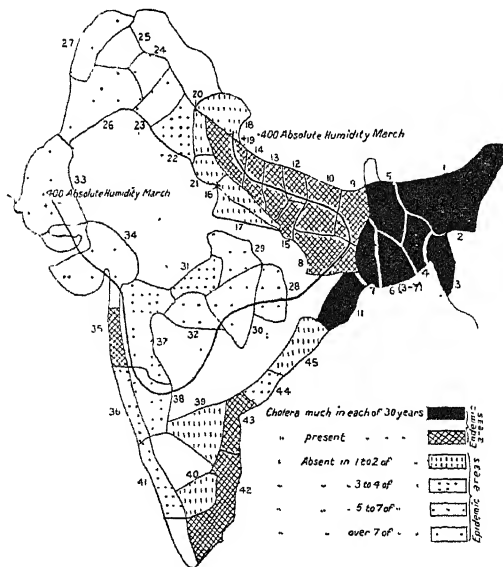


FIG. 15.—Cholera endemic and epidemic areas. For key see Fig. 14

in the different divisions of India. It will be observed that all the darkly shaded areas, indicating widespread cholera in the cold season, are in the north-east and south-east divisions, and to a somewhat less degree in the narrow Konkan coast of Bombay. To the east and south of this line the absolute humidity remains above 0.400 through the minimum cold season. All the rest of India, with absolute humidities below 0.400, show extremely low winter cholera rates not exceeding 1 in 100,000. The divisions with high winter rates are the endemic areas of cholera in which the disease is present every year (see Fig. 15), and they include (1) a large north-east endemic area of Assam, Lower Bengal, and Bihar, to which must be added the eastern and Sub-Himalayan divisions of the United Provinces in which cholera does not entirely die out in the winter months, and where it first recrudesces in April and May with the rise in the absolute humidity to over 0.400, and is not wind-borne as Bryden thought; (2) a large densely populated part of south-east Madras; and (3) the low-lying East Coast of the Bombay Presidency between the Indian Ocean and the Western Ghat mountains. On the other hand, the north-west and central portions of India, with minimum winter absolute humidities well below 0.400, constitute the epidemic areas from which cholera may be completely absent for a year or two, especially before the railway system became general, and which are liable to be invaded not only from Bengal as formerly thought, but from the three endemic areas, as was clearly the case as far back as in the great cholera epidemic of 1875-7. The previously unexplained decline of cholera incidence in January and February, following the initial yearly rise in October to December in the Assam-Bengal area, is now seen to be due to the absolute humidity falling to near the critical point of 0.400 in the coldest months of the year. The spread of cholera from the three endemic areas just defined was confirmed by a study of forty-five yearly maps of the incidence of cholera in forty-five divisions of India (1928). These show more frequent epidemics in the United Provinces than in Bengal due to recrudescences in the former and not to a spread from Bengal.

It has long been known that the most widespread and fatal cholera epidemics have arisen in famine years, resulting from failure of the previous monsoon and winter rains, as in 1875, 1892, and 1900 with death-rates per thousand of 3.39, 3.50, and 3.70 respectively, as compared with the exceptionally low rates of 0.64 in 1880, 0.78 in 1898, and 0.30 in 1893, in which years the disease was largely confined to the endemic areas, whereas in the 1892 epidemic, for example, every division of India was involved and the disease reached epidemic proportions in the north-west and in parts of the Central Provinces, Bombay, and Madras, in all of which the previous rainfall had been deficient (see Figs. 16 and 17). It is also significant that in the low cholera year 1898 the only division with an excessive mortality was the Assam valley, which was also the only one in which the previous rainfall had been deficient.

*Deficient
rainfall and
cholera
epidemics*

Further, a study of the 41 cholera epidemics in 45 years revealed that in no less than 40 the previous rains had been deficient in the areas affected. The one exception, in 1894, was readily explained as it originated in the twelve-yearly very large Allahabad Kumbh Pilgrim

Fair, attended by three million pilgrims, and the outbreak was aided by exceptionally favourable high absolute humidity for the season.

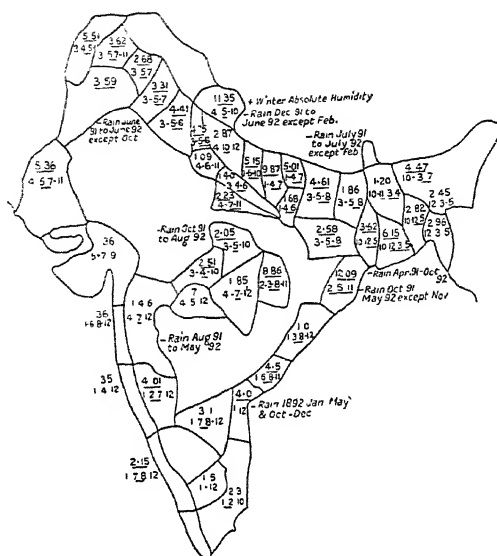


FIG. 16.—Cholera incidence in 1892, 3.5 per cent

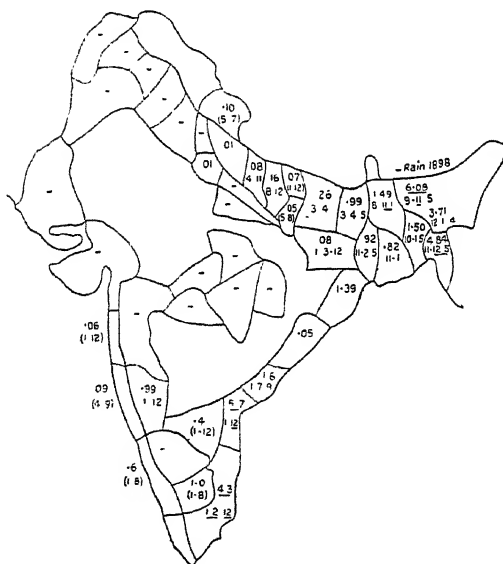


FIG. 17.—Cholera incidence 1898, 0.70 per cent

Deficient rainfall results in scanty and bad water supplies, and the aggregation of labour in huge famine camps also favours outbreaks of cholera.

Cholera epidemics spread in the hot season of March to June and tend to continue during the south-west monsoon months of July to September; and as they so largely depend on failures of the monsoon in the previous year, often aggravated by deficiency of the comparatively low winter rains, there is ample time to forecast the more important outbreaks.

*Forecasts
of cholera
prevalence*

Two other factors must be taken into consideration. In the first place, epidemic prevalence in any particular division or district appears to produce some degree of immunity, thus preventing a severe recurrence of the disease in the following year, even though it may be raging in a neighbouring district that had suffered less in the previous year. On the contrary, any area that has suffered little or not at all in the previous two or three years is liable to an exceptionally severe outbreak following deficient rains.

In the second place, high seasonal absolute humidity at the time of an outbreak will increase the severity and extent of the epidemic, as in 1894 in relation to Allahabad already mentioned. But at the same Kumbh Fair in 1882 a severe outbreak among the pilgrims in the camp spread to a much less extent than in 1894, and this was found to be due to an exceptionally low seasonal absolute humidity at the time of the 1882 Fair. It is still more significant that cholera epidemics regularly originating in relation to the Allahabad Kumbh Fairs, always involve Bihar to the east, and the eastern divisions of the United Provinces to the west, but they have little or no tendency to spread to the western divisions of the United Provinces only twelve hours by rail from Allahabad, because in those areas the absolute humidity is well below the critical point of 0.400 at the time of the Fair in January and February. On the other hand, the Hardwar Fairs, held near the western border of the United Provinces in March or April, when the absolute humidity has risen above that point, very frequently spread cholera over the west of the United Provinces and the neighbouring Punjab, and on several occasions it has overrun Afghanistan and reached Europe as already pointed out. Furthermore, at the pilgrim centre of Pandarpur in the Bombay Deccan, the July Fair, held at a time of high absolute humidity, commonly spreads cholera whenever it is prevalent in the neighbourhood. At the time of the April Fair the absolute humidity is ordinarily below 0.400, and it is very significant that during forty-five years the only four in which cholera epidemics broke out in connexion with the April Fair all showed exceptionally high absolute humidities favourable to the spread of cholera; and in 1927 such an epidemic was correctly forecasted on the lines described by the local sanitary and medical officer, and duly occurred after the civil authorities had declined to act on his advice to cancel the Fair.

The results of published forecasts made in England by the writer (1933) for three consecutive years from the meteorological data sent from India showed that in spite of the previous monsoon rains having

*Results of
cholera
forecasts*

been about normal, and therefore not very favourable for forecasting, in the two years with fairly widespread cholera, the increase or decrease on the previous year was correctly forecast in 14 and in 12 respectively of the 15 divisions dealt with, and in the remaining year an incidence well below the average was correctly foretold—an unexpectedly favourable result in years of good monsoon rains and one of practical importance.

*Pilgrims and
the spread
of cholera*

In addition to the frequent serious cholera epidemics following large fairs at Allahabad, Hardwar, and Puri in Orissa, the great importance of this factor will be evident from the simple fact that every year some twenty million pilgrims travel to and from the innumerable fairs of India, and any fair taking place at a season with suitable climatic conditions may spread the disease. For example, it was shown by the writer that the repeated importation of cholera by returning Punjab-Hardwar pilgrims is clearly the outstanding feature of the history of the disease in this province from 1867 to 1923. It is not only the danger of outbreaks at the pilgrim camps, but still more the movement of millions of pilgrims through the extensive and densely populated endemic areas of India that is mainly responsible for cholera epidemics in relation to the fairs.

The writer therefore advised that since cholera outbreaks can so often be foreseen from studies of meteorological and other data, much might be done towards limiting the spread of cholera in India if pilgrims going to or returning from dangerous areas could be given protective inoculation against the disease. Unfortunately the suggestion to use this means of trying to minimize the anticipated outbreak at the Allahabad Kumbh Fair of 1930 was not considered feasible by the civil authorities, and 147,000 persons perished in a terrible epidemic in Bihar following the Fair, and 30,000 more in the eastern area of the United Provinces, where fortunately the absolute humidity at the time of the outbreak was not so favourable as in Bihar. In the Central Provinces something has been done in recent years on a voluntary basis towards the inoculation of pilgrims returning from infected areas but, with the exception of Bengal, where two million inoculations were carried out in one year by C. A. Bentley, India has not yet made as full use of preventive inoculation as have Japan, China, and French Cochin-China.

*Cholera in
the Far East*

In China it appears that, although the early nineteenth century epidemics were imported from India, the disease has been endemic for several decades, especially in the Yangtse valley; and in the absence of reliable mortality statistics, the epidemics in recent years may well have been quite as serious as the better recorded ones in India. Japan and other far eastern countries have at times been infected from China.

French Indo-China suffered severely from cholera in 1926, and during the epidemic more than two million of a population of nineteen millions were inoculated. Siam also suffers occasionally.

The Philippines and Dutch East Indian islands are liable to outbreaks, such as that in 1927 at Batavia. As such outbreaks usually occur after some years of freedom from the disease it is doubtful if the disease is endemic in these countries.

From the epidemiological point of view the length of time convalescent cholera patients may harbour virulent vibrios in the intestine or the gall-bladder is of great importance. Fortunately they ordinarily disappear from the stools within four or five days after an attack of cholera. Indian patients, however, are commonly discharged from hospital within a very few days, and at an epidemic at Puri in Orissa E. D. W. Greig found virulent organisms in the stools of 36 per cent shortly before their discharge, and cholera very soon after broke out several hundred miles away, in the Central Provinces, to which many of the Puri pilgrims had been carried by rail. Again, in Mesopotamia F. P. Mackie and G. Trasler found that only 7.2 per cent of cholera convalescents remained carriers for more than ten days, and only two of several hundreds up to five and seven weeks respectively. Recent studies in Ceylon by L. Nicholls of ten years' quarantine examinations of 200,000 labourers entering from the south-east Madras endemic cholera area showed little correlation between the number of vibrios found in their stools by bacteriological examinations and the incidence of cholera in the areas of Madras from which they came, and the agglutinable vibrios rarely survived more than six to eight days, and very seldom over three weeks. This is in accordance with epidemiological evidence, for the spread of cholera in India can almost always be traced to recent acute cases in persons coming to an area previously free of the disease.

Bili-vaccine orally was reported by Jude and Millischer in Syria to free carriers from the cholera vibrios in twenty-four hours compared with five days without its use.

Ernest Hart truly said you can eat cholera and you can drink cholera but you cannot catch it. There is thus no danger in working in a properly administered cholera hospital with immediate disinfection of the evacuations and soiled linen. Explosive outbreaks of cholera occur as the result of infection of water supplies with the cholera vibrio, as in the case in 1892 of the high incidence in Hamburg, which had an unfiltered water supply, and low incidence in the contiguous Altona which had filtered water. Epidemics in India frequently result from the contamination of unprotected wells and tanks used for drinking purposes, especially at important pilgrim centres such as Puri. The supply of filtered water to Indian cities such as Calcutta greatly reduced the incidence of cholera. When cases occur sporadically, food contamination by cholera vibrios, often by flies that have fed on cholera stools, is a frequent source of infection, and is very difficult to guard against during the prevalence of the disease unless the consumption of all uncooked food, as well as of unboiled water and milk, is prohibited. Infection through soiled linen is also a danger, and in a terrible

Carriers

*Infection by
food and
water*

Lucknow outbreak among British troops in 1894 inefficient filters were a direct cause.

*Predisposing
causes*

Cholera is disposed to by the following conditions. Chills, such as those due to a punka, may in the tropics cause simple diarrhoea and thus dispose to cholera infection. Fasting, as well as intense fear of the disease, have a similar effect through inhibition of the secretion of the gastric juice, the normal amount of hydrochloric acid in which may prevent the cholera vibrios from reaching the small bowel and producing infection. For this reason the great Mahomedan Ramazan fast favours cholera attacks if the disease is prevalent, for infected water taken on an empty stomach at sunset after fasting all day is particularly dangerous and may be followed by a fatal attack of the disease in the early morning. Saline purges also encourage the multiplication of cholera vibrios in the bowel and should be avoided when the disease is prevalent. In Calcutta it has been observed that persons coming from areas usually free from cholera to this endemic area suffer more than the local inhabitants, apparently because the latter have acquired some immunity from repeated contact with the disease.

2.—BACTERIOLOGY

*The cholera
vibrio*

The early difficulties in the differentiation of the cholera vibrio from the numerous closely similar non-pathogenic vibrios were overcome when in 1894 Pfeiffer discovered the serum agglutination test. The cholera vibrio, or comma bacillus as it was first called, is a non-sporing short curved rod 1.5 to 2μ in length by 0.3 to 0.4μ in breadth. It is motile with a single terminal flagellum, which serves to differentiate it from other water vibrios with numerous flagella. It is aerobic but facultatively anaerobic, and grows readily on ordinary solid and fluid media; it does not produce fluorescence or pigment in peptone water, but it gives the cholera red ('nitroso-indol') reaction on the addition of a few drops of pure sulphuric acid, owing to the formation of indol from protein material in the broth and the reduction of nitrates into nitrites. In a stab culture in gelatin it produces funnel-shaped liquefaction along the line of inoculation and spreads over the surface of the medium. It is non-haemolytic and differs in this respect from the El Tor vibrio isolated from suspected carriers by Gotschlich at the Egyptian quarantine station at a time when cholera was not prevalent; E. D. W. Greig found that all his 333 strains cultivated from cholera cases in Calcutta were non-haemolytic. The cholera organism is readily stained in one to two minutes by basic aniline dyes, such as 1 in 5 Ziehl-Neelsen's carbol-fuchsin solution, and is Gram negative. Cultures are polymorphic owing to numerous degenerative involution forms. In tissues it can be stained with Loeffler's methylene-blue in acetic acid and alcohol. It usually ferments mannitol, but not lactose.

In examining a cholera stool for the vibrio one of the white flakes

should be selected, stained with carbol-fuchsin and examined microscopically for vibrios. In severe cases they may be present in nearly pure culture and can be isolated by direct smears on suitable media. When less numerous or scanty, a loopful of the stool should be placed in a flask on the surface of 1 per cent alkaline peptone water with a pH of 8 to 9. On incubation for 6 to 8 hours at 37° C. a nearly pure surface culture of the vibrio will develop, from which a plate of Dieudonné's alkaline blood agar should be inoculated, or if the vibrios are still scanty a subculture in peptone water may first be made, as by this means the vibrio may readily be isolated. To examine water suspected to contain the vibrio 100 c.c. of peptone solution should be added to 900 c.c. of the water and the above procedure followed.

Selective media for isolation of the organism

If a suitable animal, such as a rabbit, is injected intravenously with true cholera vibrios the serum of the animal develops both antitoxic and bactericidal properties, chiefly the latter, of such a degree that it will agglutinate true cholera vibrios in the high titre of 1 in 10,000 to 1 in 40,000, but has no such effect on non-choleraic vibrios. Colonies of vibrios obtained by culture from the stools of suspected cholera cases can be tested on a glass slide to see if they are agglutinated in high dilutions by such a serum, and subcultures can be made from any positive colonies. During several years' work in Calcutta E. D. W. Greig found that during the height of the cholera season vibrios giving typical agglutination could be isolated from all cholera cases, but at the end of the season during the decline of the outbreak para-cholera vibrios might occasionally be obtained which agglutinated in a high titre only with a serum obtained by injecting rabbits with such strains. Further, non-choleraic water vibrios will in rabbits produce sera that will agglutinate themselves, but not true cholera vibrios. During convalescence of some cholera patients vibrios with weak or absent agglutinating power may be recovered from the stools, probably transitional forms, and it has recently been suggested that they may possibly be produced by the action of bacteriophage on true cholera vibrios.

Serology

A further complication has been introduced by the discovery that subcultures from a single colony may dissociate into smooth and rough colonies, and that the latter tend to lose their virulence and agglutinating powers and are therefore not suitable for making vaccines.

Smooth and rough forms

Precipitins have been described which appear to be the same as agglutinins. Complement fixation is more complicated than agglutination and presents no advantages. Cholera vibrios after long sojourn in water may show some serological transformations, but they retain their agglutinating powers. The position of atypical vibrios is still unsettled, but they do not appear to have much practical importance in the epidemiology of cholera.

Greig found that during the first two days of a cholera attack the serum of the patients does not agglutinate cholera vibrios and little

Serum reactions

such power is developed before the fifth or sixth day; this test is therefore not of diagnostic importance except occasionally to determine if a convalescent patient has suffered from the disease.

*Bacterio-
phages*

Twort (1915) and d'Herelle (1917), and subsequently Malone, drew attention to the action of bacteriophage in disintegrating and dissolving bacteria in cultures, by the action either of an enzyme according to one theory, or an ultramicroscopical virus according to recent work. There is also disagreement regarding F. d'Herelle's view that there is only one bacteriophage that acts on a number of bacteria. When an active bacteriophage is added to a fluid culture of cholera vibrios the fluid is cleared within a few hours by the wholesale dissolution of the organisms, but after a time it becomes hazy again owing to the renewed multiplication of a few vibrios that were resistant to the strain of bacteriophage present. If bacteriophage is present in plates of the vibrios clear areas will develop where dissolution of the organisms has taken place. A number of strains from A to J have already been isolated by I. Asheshov, J. Morison, and others in India, and in order to obtain complete dissolution of cholera vibrios all of them must be present in highly virulent fairly fresh cultures. Strains can be preserved for a time in sealed ampoules.

It has been claimed that bacteriophage is absent from the stools of the most virulent cases of cholera, but present in mild and convalescent cases, and recovery has been attributed to the ability of bacteriophage to convert highly agglutinating virulent vibrios into non-agglutinating avirulent ones. Further, Doorenbos reported in 1932 that he had changed non-haemolytic into haemolytic vibrios and that the El Tor strain is a true cholera contaminated by phage. The already confused state of the bacteriology of cholera has thus been still further complicated by bacteriophage research.

*Antigenic
structure
of cholera
vibrios*

Elaborate biochemical studies by R. W. Linton show that true cholera vibrios usually contain galactose, and the harmless water vibrios arabinose, and both these substances have been found in cholera stools. The El Tor vibrios are said to present a chemically distinct group.

*Animal
infections*

R. Koch originally produced a choleraic diarrhoea by feeding rabbits on cholera vibrios after neutralizing the acid of their gastric juice, and Metchnikoff obtained a more typical condition by feeding suckling rabbits with a simpler intestinal flora, but the difficulty in readily producing characteristic animal infections has handicapped research. Greig produced choleraic symptoms both by intravenous injections of large quantities of freshly-obtained cholera vibrios and also by feeding by Koch's method; he recovered the vibrios from the heart blood, intestines, and gall-bladder, and he found them months afterwards in the gall-bladder, sometimes associated with gall-stones.

Toxins

The toxicity of cholera vibrios is mainly due to an endotoxin as shown by Kolle. French workers have also described a soluble exotoxin, but it is very difficult to prove this because endotoxins are set free when

numerous vibrios die and discharge their endotoxins into the medium. Emmerich long held that the symptoms of cholera are due to the absorption from the bowel of nitrites formed by the action of the vibrios on the nitrates present there, but this has been disproved by the fact that typhoid and dysentery bacilli are equally good nitrite producers.

3.—PATHOLOGY

The most remarkable fact about cholera is that in the most acute cases the very varied normal intestinal flora may be practically completely replaced within a few hours by an almost pure culture of the cholera vibrio, enormous numbers of which are constantly disintegrating and setting free their endotoxins to be absorbed through the damaged intestinal mucous membrane. Equally striking is the rapidity of the disappearance of the vibrios, usually within a few days, during convalescence. Comparatively few of the organisms appear to enter the system, for Greig failed to cultivate them from the blood in human infections, and obtained only very small numbers by cultures from the internal organs in fatal cases, except in the highly toxic pneumonic complication in which they could be demonstrated microscopically in the lung lesions. He also cultivated them from the gall-bladder in 80 out of 271 necropsies, in 12 of which naked eye lesions of cholecystitis were present.

*Distribution
of vibrios
in the body*

The destructive action of the vibrios on the epithelial lining of the mucous membrane causes it to be shed, with the result that fluid pours out from the blood into the lumen of the bowel and the toxins are absorbed into the system, leading to collapse of the patient from failure of the circulation. The changes found in cases fatal during this acute stage are mainly due to the great loss of fluid. The serous cavities are free from fluid, and petechial haemorrhages may be seen on the pericardium. The lungs are dry and light in weight, and on applying pressure to their cut surfaces thick tarry blood exudes from the large vessels. The peritoneal surface of the small intestine is sticky and congested, its mucous membrane is greatly congested, and the lymphoid follicles of the ileum, as well as the Malpighian bodies in the spleen, are often very prominent; the low percentage of lymphocytes in the blood is thus explained. The stomach and the upper part of the colon may also be congested and show haemorrhages into the mucous membrane. The gall-bladder may be congested and so distended with thick bile that it requires considerable pressure to force any bile into the highly congested duodenum; this accounts largely for the absence of bile from the typical rice-water stools.

*Morbid
anatomy*

The kidneys show intense congestion and microscopically small inter-tubular haemorrhages. The writer found that it took from 80 to 100 mm. Hg pressure to force fluid through the renal circulation, as against 20 to 30 mm. in ordinary cadavers; this accounts for the complete suppres-

Kidneys

sion of urine during the collapse stage with a blood-pressure below 70 mm. Hg.

Blood changes

Blood changes are even more important and furnish the key to the successful modern treatment of the acute cases. The great loss of fluid from the blood is first evidenced by the rise in the red corpuscle count from five to seven or eight millions, so that on opening a vein the blood may slowly exude, in extreme cases almost like tar. The loss may most accurately be estimated by defibrinating a few drops obtained by pricking a finger and then centrifuging in a graduated capillary tube, to allow the relative volumes of the red corpuscles and of the serum to be noted. The normal proportion is 45 per cent of red corpuscles to 55 per cent of serum, but in very severe cases the percentage of red corpuscles may rise to as much as 72, with only 28 per cent of serum. Approximate estimations of the loss of fluid from the blood can thus be made, and from a series of such observations the writer found that in mild cholera cases not going on to collapse the loss of fluid from the blood averaged 35 per cent; in collapsed cases recovering after injection of hypertonic salines intravenously as described below the loss averaged 49 per cent; but in the extremely severe cases ending fatally in spite of the saline injections the average loss of fluid from the blood was no less than 64 per cent, or practically two-thirds.

Loss of salts

The loss of salts from the blood is equally important, for the writer's estimations of the chlorides in the sera of cholera patients showed that, in spite of the great concentration of the blood, they may in the most severe cases be even below normal; the salts are thus lost to an even greater extent than the fluid; this was explained by finding a large amount of chlorides in the rice-water stools. Injection of hypertonic salines to replace the lost salts is therefore indicated. It was pointed out by Benjamin Moore that chlorides combine with toxins in the blood and cause their excretion through the kidneys; this furnishes an additional reason for their employment.

Reduction of alkalinity

The reduction in the alkalinity of the blood is another important change, for A. W. Sellards (1910) in the Philippines observed that large doses of sodium bicarbonate orally failed to make the urine alkaline in cholera, and in 1915 A. J. Shorten and L. Rogers in Calcutta found a material reduction in the alkalinity of the blood in all severe cases; moreover they found that when it fell to centinormal or less (estimated by Almroth Wright's method) fatal uraemia always ensued. The systematic administration of alkalis is therefore indicated from the first to prevent this serious complication. The above blood changes were confirmed in Japan in 1922 by Tsurumi and Toyoda.

Leucocytosis

There is an increase in the white count, 15-20,000, with a great diminution in the lymphocytes and a rise in the large mononuclears; it thus differs from the polymorphonuclear leucocytosis of arsenical poisoning.

4.—CLINICAL PICTURE

The incubation period is usually from twelve hours to three days, but may occasionally be as long as a week. In the classical Calcutta case recorded by N. C. Macnamara, in which nineteen persons accidentally swallowed water contaminated by a rice-water cholera stool, only five developed cholera, all between 24 and 72 hours. *Incubation period*

Cholera is characterized by copious, nearly painless watery diarrhoea varying greatly in degree from loose faecal stools not recognizable without bacteriological examination as choleraic, up to the typical colourless stools containing small white flakes of shed intestinal epithelium, causing it to resemble water in which rice has been boiled. On standing, the white particles sink leaving the supernatant fluid clear. In severe cases with congestion of the upper colon they may be pink from the presence of blood. Two to four quarts may be passed within two or three hours, sometimes in an almost continuous stream, soon leading to collapse with complete disappearance of the radial pulse. The absence of bile accounts for the colourless character of the stools; its reappearance is a favourable sign. *First stage of copious evacuations*

‘Cholera sicca’ is a term applied to the very rare fulminant cases in which the watery fluid is poured out so rapidly into the small bowel that fatal collapse may occur while walking in the street without the passage of a single stool; at necropsy the small bowel may be full of the typical opalescent colourless fluid. The importance of these cases lies in the proof they afford of the hopelessness of the most extreme cases of cholera. *Cholera sicca*

Vomiting of large quantities of watery fluid, such as a quart at a time when little or no water has recently been taken, is almost pathognomonic of cholera when it accompanies the typical rice-water stools, and it may be an important factor in bringing about collapse of the patient. In some cases hiccup may be very troublesome and persistent, but is not in itself a sign of danger. Abdominal pain in the form of a burning sensation may be severe, but apart from cramps of the abdominal muscles it is not always prominent. *Vomiting*
Hiccup
Pain

The general condition of the patient as the disease progresses is characterized by a cold clammy shrivelled state of the skin with an axillary and even a mouth temperature of 95° F. or less, and the tongue may actually be cold to the touch. At a time when the surface temperature is far below normal, the rectal temperature may be much above normal and the writer has seen it reach the hyperpyrexial level of 108° F. in a cold collapsed patient. The eyes become sunken. In severe cases cyanosis of the fingers and lips is a sign of grave toxæmia, and when accompanied by restlessness and cramps is an indication for immediate saline transfusion. The pulse becomes thready and then disappears at the wrist, and even from the brachial artery; when the pulse still remains the blood-pressure may fall below 70 mm. Extreme *General condition of patient*

thirst may be relieved by giving fluid freely by the mouth even if much of it is vomited. Suppression of renal excretion will be complete during collapse for the reason mentioned above.

Cramp

Muscular cramps are a prominent and very distressing feature of the collapse stage. They begin—accompanied by local cyanosis—in the distal portions of the extremities owing to the failure of the circulation, and spread up the limbs to the abdominal muscles, contributing materially to the exhaustion of the patient. Their presence is also a reliable indication for immediate active treatment to compensate for the great loss of fluid which is their main cause. They are particularly severe in young muscular subjects who are so often the victims of cholera.

Duration of collapse stage

The collapse stage may last from a few hours in comparatively mild cases to two days in very severe ones, and may recur repeatedly for several days after having been relieved by saline transfusions, with ultimate recovery of the patient. The mind remains quite clear in uncomplicated cases even during collapse, much to the aggravation of the patient's sufferings.

The stage of reaction

Patients who survive the collapse stage gradually pass into the reaction stage. The diarrhoea becomes less acute, and after a time the stools become less watery and bile reappears in them as subsidence of the congestion of the duodenum allows its entry. The pulse gradually recovers with a rise in blood-pressure, warmth returns to the extremities, and the muscular cramps, restlessness, and cyanosis disappear. The dangers, however, still remain; indeed, before the introduction of the modern treatment, the older Anglo-Indian writers rightly regarded the reaction stage as hardly less dangerous than that of collapse on account of its frequent complication with excessive febrile reaction or continued suppression of urine with fatal post-choleraic uraemia.

Febrile reaction

Norman Chevers (1886) correctly described cholera as a fever, but one in which the outward signs of the initial rise of temperature are suppressed during the collapse stage. Remarkable confirmation of that view is afforded by a case observed by the writer in which the initial febrile rise of smallpox was completely inhibited by its coinciding with the collapse stage of cholera. There may be, however, as already mentioned, a high rectal temperature during collapse, and with circulatory recovery and return of active absorption of the toxins from the intestine, the surface temperature rises several degrees above normal, except in hopeless cases with complete exhaustion of the powers of recovery. Unless great watchfulness is observed there is a serious risk of hyperpyrexia, with inevitable death from toxæmia if consciousness is lost, for this toxæmia does not respond to the measures to reduce the bodily heat which are so often effective in heat-stroke. This danger is also shown by the fact that in eleven years at the Calcutta European Hospital, when intravenous salines were not used, the case-mortality was 81·6 per cent, 62 per cent of the deaths occurring in the collapse stage, 15 per cent from post-choleraic uraemia, and the remaining 23 per cent during the

reaction stage from toxæmia and excessive febrile reactions with temperatures generally from 105° to 106.8° F.; all the patients with temperatures above 103° F. died in this stage. As intravenous salines bring about early reaction great care is necessary to prevent it from becoming excessive (see Fig. 18), although there is no difficulty in doing so with the precautions described in the section on treatment.

The other grave danger during the reaction stage is failure to restore the normal excretion of urine, with continued complete or partial suppression of the collapse stage and ultimate death from uræmia. *Post-choleraic uræmia*

The urine passed during the acute stage is concentrated and contains a considerable amount of albumin with a small amount of urea and *The urine*

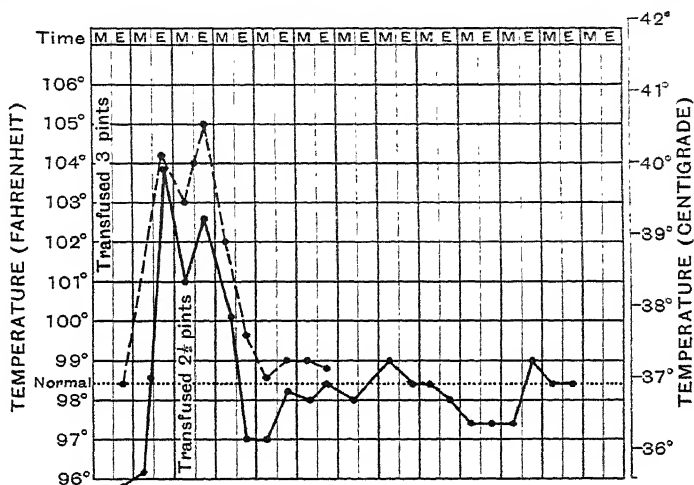


FIG. 18.—Febrile reaction after two hypertonic saline injections given within twelve hours. The dotted line represents rectal temperature. (From the Author's *Bowel Diseases in the Tropics*)

total solids during the first two or three days. During the reaction stage in favourable cases the quantity of urine passed rapidly increases, the albuminuria gradually decreases and the urea increases showing resumption of the normal functions of the kidneys; and when two pints of urine of approximately normal composition are passed in twenty-four hours the danger of uræmia is over.

Post-choleraic uræmia is common in (1) very severe cases with persistent or recurring collapse accompanied by complete suppression of urinary excretion, continuing to a greater or less degree during the reaction stage, and (2) in milder cases inefficiently treated during the stage of copious evacuations, and admitted on about the third day for suppression of urine; the treatment of these cases is often very difficult because the alkalinity of the blood is already markedly reduced on their admission. Even a slight degree of granular kidney greatly favours the occurrence of uræmic complication as shown by post-mortem records. *Incidence of uræmia*

In all cases of cholera careful records should be kept of the urine passed in each twelve-hour period, and if it amounts to a few ounces only, steps should at once be taken to ascertain the reason. A moderate degree of continued concentration of the blood may be revealed by a specific gravity between 1056 and 1062 in spite of a good pulse and blood-pressure, and this can be easily remedied by an alkaline saline transfusion. More frequent and difficult to deal with is a persistent blood-pressure in an adult of under 100 mm. Hg in spite of a very fair pulse; for with the great congestion of the kidneys in cholera, such a pressure does not suffice to maintain the excretion of urine. In feeble Indian subjects over the age of 50 a blood-pressure that does not rise above 80 to 90 mm. always ends in fatal uraemia. Regular estimations of the blood-pressure and of the specific gravity of the blood should therefore be made every twelve hours, as well as whenever the urine is deficient throughout the reaction stage.

An estimation of the reduction of the alkalinity of the blood will reveal the degree of danger of uraemia.

Sequelae and complications

In former days the few patients who recovered from severe collapse were liable to serious sequelae, such as sloughing of the cornea, gangrene of the fingers, toes, penis, or scrotum, but under modern treatment none of these conditions were seen among more than 2,000 consecutive cases. In the earlier trials of hypertonic salines parotid suppuration, usually yielding to early incision, was occasionally met with.

Cholecystitis with pain in the region of the gall-bladder occurs in about 1 per cent of cases, but it is readily amenable to medical treatment and does not require surgical interference.

Pneumonia with small patches of consolidation, difficult to detect by physical signs, and due to the presence of cholera vibrios in large numbers in the pulmonary lesions, is a highly toxic and very fatal complication in 2 or 3 per cent of cases in the later stages, and one that, according to Wall, is more common in colder than in hot climates. It may be suggested by pain in the chest and accelerated breathing.

Abortion or premature delivery is frequent in badly collapsed pregnant patients, and, as the child always succumbs to the toxæmia, Philippine workers advise the early removal of the dead foetus, for by that means they reduced the high mortality among the mothers to that of patients without this complication.

Convalescence

Convalescence is remarkably rapid considering the grave nature of the disease, but danger of sudden cardiac failure from sitting up too soon must be guarded against.

5.—PROGNOSIS

Mortality

The mortality depends mainly upon whether or not the modern treatment is available. Formerly the case mortality in Indian hospitals, jails,

and Indian regimental hospitals was approximately 60 per cent, but in European civil and regimental hospitals it was about 80 per cent. Cases admitted to hospitals are on the average more serious than the total cases in villages, which have about 50 per cent of deaths on the average. The mortality is always considerably higher at the beginning of an outbreak than at the end, the difference sometimes amounting to 50 per cent. In the Calcutta Medical College Hospital the case-mortality formerly varied from nearly 70 per cent at the beginning of the cholera season in the first quarter of the year to about 50 per cent in the rainy season of June to October; whereas under the new system of treatment described below the figures for the same seasons were respectively 27 and 18 per cent. The yearly case-mortality in the same hospital was 59 per cent in the eleven years before, and 20·8 per cent in 1,429 consecutive cases after the introduction of the improved treatment. European patients did even better than Indians, as did Chinese patients at Shanghai, owing to their good racial stamina. In China the hypertonic saline treatment was first used in Harbin in 1919 with a case-mortality of 14·11, against 33·75 and 57·77 in two other hospitals using normal salines subcutaneously, and in 1926 the respective figures were 17·3 and over 50 per cent.

The prognosis in individual cases under the present system of treatment depends on the following points. In former days not over 10 per cent of patients who became completely collapsed recovered; now under favourable conditions 70 per cent of collapsed patients can be saved, including extreme cases indicated by specific gravities of the blood above 1070. The following data are based on an analysis of 836 carefully recorded Calcutta hospital cases. The degree of loss of fluid from the blood as shown by its specific gravity made little difference, for with readings of 1063 to 1066, indicating losses of three to five pints of fluid from the blood, the case-mortality was still only 20·6 per cent, and only 23·4 per cent with the very high readings of 1067 to 1071. The blood-pressure is a better guide to prognosis, for 91 per cent of those admitted with a blood-pressure above 70 mm. recovered, against 73·4 per cent with readings between 50 and 70 mm., and 70 per cent in those without a perceptible pulse at the wrist—the last two classes including no less than 65·3 per cent of the total admissions.

*Factors
influencing
prognosis*

*Blood-
pressure*

The age of the patient is most important in prognosis. The mortality is highest in children under five years of age with little resisting power, and in Indian subjects the death-rate increases rapidly with each decade after 40, to reach 50 per cent in those more than 50 years of age. Among those of the latter who survive the collapse stage, especially among vegetarian Hindus with little stamina, it is difficult to maintain a sufficiently high blood-pressure to avert uraemia. The duration of the disease on admission is of importance in relation to the mortality from post-choleraic uraemia, for in 50 per cent of such fatalities the patient was admitted more than twenty-four hours after the onset of the disease and had established suppression of urine, which is always serious if it

Age

*Time of
admission
to hospital*

has persisted for more than one day and becomes increasingly grave with each day that passes. Before the systematic use of alkalis, cases with two days' complete suppression ended fatally; now, however, some cases of this kind recover, provided the alkalinity of the blood has not fallen as low as centinormal.

*Other factors
influencing
prognosis*

Other serious signs are repeated collapse after saline transfusions, a rectal temperature down to 97° F. or over 104° F., a respiratory rate of over 40 per minute, together with cyanosis and restlessness indicating severe toxaemia. During the reaction stage hyperpyrexia is very dangerous, for if unconsciousness ensues, recovery, owing to the toxic nature of the illness, never occurs in the writer's experience. Pregnant patients are liable to do badly unless the foetus, which is always dead in badly collapsed patients, is removed artificially without delay. Anaemic patients and others in feeble health show little power of resistance to cholera. From its highly toxic nature pneumonia is a grave complication. Duncan Whyte in China reported that opium eaters and smokers are especially prone to fatal uraemia, and alcoholics were also found to do badly. On the other hand Wu Lien-Teh concurs in the statement of an American Red Cross worker during the 1919 China epidemic, that almost anybody can be saved from cholera by good nursing and careful attention to details of treatment.

6.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

During the epidemic prevalence of cholera there is seldom any difficulty in its recognition as the cases are mostly of the typical acute form, frequently several in the same house. Towards the end of an outbreak some cases are liable to be milder and less characteristic, but even in endemic areas atypical sporadic cases are exceptional. During the prevalence of cholera it is best to suspect all cases of diarrhoea.

*Diagnosis
from food
poisoning*

Food poisoning resembles cholera in the acuteness of the diarrhoea, sometimes attended by collapse, and the occurrence of more than one case in a household. On admission of such a collapsed patient it may be impossible to distinguish between the two diseases until a stool is passed, which in food poisoning will not present the colourless rice-water appearance of cholera. Fortunately, in cases requiring immediate treatment for dangerous collapse, that described below for cholera is equally effective in food poisoning, as shown by the writer who saved two very severe cases admitted to his cholera ward in a collapsed condition by giving hypertonic salines intravenously. Mushroom poisoning is also said to resemble cholera. Summer diarrhoea in infants often responds to the same treatment, but in my experience such cases are fewer than might be expected in the tropics, probably on account of the special care taken to sterilize milk by boiling.

*From
summer
diarrhoea*

*From algid
malaria*

Algid malaria, on the other hand, requires totally different treatment and its early recognition is therefore of vital importance. The routine

measurement of the specific gravity of the blood at once reveals low readings due to the anaemia of acute malaria, instead of the high figure of collapsed cholera, and a microscopical examination of the blood shows the presence of malarial parasites. The leucocyte count may also be diagnostic, for although in both the percentage of large mononuclears is raised, in malaria the proportion of lymphocytes is normal or increased, but in cholera greatly decreased, and the leucocytosis of the latter condition is absent in malaria.

Very acute bacillary dysentery may for a time be regarded as cholera from the acute diarrhoea and collapse due to the toxæmia. Here again hypertonic salines intravenously proved the best immediate treatment in the hands of the writer in Calcutta, and subsequently in war cases in the Near East. Later observations of the stools show the true nature of the case. *From dysentery*

Arsenic poisoning is common in India in regions where cholera is endemic, and may easily be mistaken for cholera owing to the acuteness of the diarrhoea. Epigastric pain is, however, much more prominent, and the writer found that, although leucocytosis is present in both, in arsenical poisoning it is polymorphonuclear as the result of inflammation of the gastric mucosa and not of the type found in cholera (see p. 178). *From arsenic poisoning*

Moribund patients are liable to be admitted to a cholera ward, but the absence of increased specific gravity of the blood will usually exclude cholera.

A simple and rapid bedside method of estimating the specific gravity is with small bottles containing glycerin and water solutions, made up with the help of a specific gravity bulb, each solution varying two points, from 1040 to 1070. A few drops of blood from a pricked finger is drawn up into a capillary pipette and a small drop is expelled gently into the middle of a bottle. If it sinks it is heavier than the solution and the process is repeated until it just floats for a few moments; this gives the correct reading; or if it sinks say in 1063 but rises slowly at first in 1065 the intermediate figure of 1064 is that required. The normal specific gravity of a previously healthy patient's blood is 1056 to 1058, and if it has risen to 1063 or over, a serious loss of fluid from the blood has already taken place. *Estimation of specific gravity of blood*

7.—TREATMENT

From the foregoing account of the modes of infection it follows that during cholera prevalence no uncooked food or unboiled water or milk should be consumed. Latrines should be disinfected with fresh chlorinated lime, which repels flies, and all evacuations and soiled linen of cholera patients at once placed in a disinfectant. *Prophylaxis*

Wells should be disinfected immediately an outbreak occurs, as first advised by E. H. Hankin in Agra, by dissolving 1 to 2 ounces of

potassium permanganate in water and adding sufficient of this solution to make the well water pink; this is harmless to drink after a day or so. In the case of larger collections of water, such as tanks, fresh bleaching powder, or better still chloramine or chlorine prepared by electrolysis, should be used; and, as they are cheaper than permanganates, they may also be used in wells. Many instances of striking reduction of cholera have been reported to follow such measures. The protection of all food substances from flies may once more be emphasized.

*Anticholera
inoculation*

Owing to the great difficulties in safeguarding water and food in such countries as India, prophylactic inoculation affords the best protection against the disease, and should be carried out as soon as an outbreak of cholera threatens or begins. Living cholera cultures were first used for this purpose with some success by J. Ferran in Spain in 1885, and in 1892 Haffkine modified the method by first giving a weak strain and a week later a virulent culture. Soon after, Kolle demonstrated that the injection of dead cultures produced powerful bactericidal and agglutinating properties in the serum of the treated animals and advised the use of a carbolized vaccine. Sensitized vaccines prepared by treating the cultures with antitoxic serum, to lessen any remote chance of a negative phase of temporary increased susceptibility, have been used extensively in Japan; bili-vaccines in pill form in three doses orally were found by A. J. H. Russell in Madras to have some protective powers, but not to present any advantages over injection as they are more troublesome and expensive and may themselves cause severe diarrhoea.

When the circumstances permit it is best to give 1,000 million dead vibrios in 1 c.c. for the first dose and double that amount a week later, and the immunity can be further enhanced by a third similar dose after another week. In India during recent years a single injection of a full dose has been used on a large scale during outbreaks without any evidence that a negative phase results. The duration of protection is probably not more than six months, but this is ample to tide over any outbreak. Vaccines should be used within three to six months after their preparation from fairly fresh active strains.

*Statistical
results of
inoculation*

The results of inoculation may be illustrated by the following examples. The writer drew up a table showing four occasions on which from 81,000 to 238,000 inoculations were followed by a reduction of the incidence of cholera, as compared with the uninoculated in the same places, of between 92 and 96 per cent after the double inoculation. In Batavia, in 1927, 62 per cent of the population were inoculated and the epidemic was suppressed. Besredka recorded the following war inoculations under conditions affording the precision of a laboratory experiment. After 386 cases with 166 deaths had occurred in a regiment of 4,500 men the epidemic continued after the first dose of vaccine, but ceased abruptly after the second. In a barrack of 180 men all but four were inoculated, and subsequently three of these four were the only men to be attacked by cholera. Furthermore, the commander of a regiment opposed inoculation, but 200 Jews insisted on being inocu-

lated; subsequently 450 cases of cholera occurred in the regiment but not one among the 200 vaccinated. C. A. Bentley reported that during an outbreak in Northern Bengal only the Hindus would at first be inoculated; the disease soon ceased among them, but continued among the uninoculated Mahomedans, whose males were then inoculated; the disease then ceased among them, but continued among the uninoculated Mahomedan females until they too were inoculated, after which the epidemic ceased.

In China good results from inoculation have also been reported; in 1932 alone more than eight million doses of vaccine were distributed over the infected provinces by aeroplane at a comparatively low cost, and there was no doubt about the efficacy of vaccines made from local strains. In Shanghai alone more than three million doses were injected in a population of three million within four years.

On admission of a cholera patient the following observations should be made. The specific gravity of the blood should be taken by means of the glycerin and water solutions described on page 185, together with the blood-pressure, if any pulse remains. The mouth and rectal temperatures should be recorded, and the presence of cyanosis, rapid respiration, and restlessness noted; the three last alone call for an immediate saline transfusion, and so does a blood-pressure below 70 mm. or a specific gravity of the blood of 1063 or above, for such a degree of concentration of the blood means that three or more pints of fluid have been lost; this should be made good without delay even if the patient is not already collapsed, in order to prevent the onset of collapse and the accompanying suppression of urine.

*Observations
on patient on
admission*

(1)—Treatment in the Stage of Copious Evacuations

As early as 1832 intravenous transfusions of physiological saline were used in a cholera outbreak in Edinburgh, with the immediate good effect of reviving the collapsed patients, but with an ultimate death-rate of over 70 per cent due to the rapid recurrence of collapse; very similar results have since been repeatedly reported. In 1897 Cox in China gave up to thirty pints of physiological saline by slow continuous intravenous transfusion with a special apparatus which made it possible to treat several patients at the same time; he met with some success in spite of occasional occurrence of dangerous oedema of the lungs. In 1906 the writer once more tried intravenous physiological saline for a year in Calcutta with the advantage of the guidance of estimates of the blood-pressure and the specific gravity of the blood, but the case-mortality fell from 59 to 52 per cent only. In 1908, for the reasons mentioned above (p. 178), he began to use hypertonic salines with an immediate reduction of the death-rate to 36.6 per cent, or about half that of the same hospital during the preceding eleven years. Later he added the systematic use of alkaline salines with a 70 per cent reduction of the mortality from uraemia; with the further addition of permanganates orally to destroy the cholera toxins in the

*Saline
transfusions*

bowel the case-mortality in 1,429 consecutive cases treated during five years fell to 20·8 per cent, or practically one-third of the former rate.

The hypertonic saline solution consists of sodium chloride 120 grains, and calcium chloride 4 grains, in one pint of sterile water, the calcium chloride being a cardiac tonic.

The alkaline solution consists of sodium bicarbonate 180 grains (2 per cent), and sodium chloride 90 grains, in one pint of sterile water. The sodium chloride solution is first sterilized by boiling; the

*Composition
of hypertonic
saline
solution*

*Alkaline
solution*

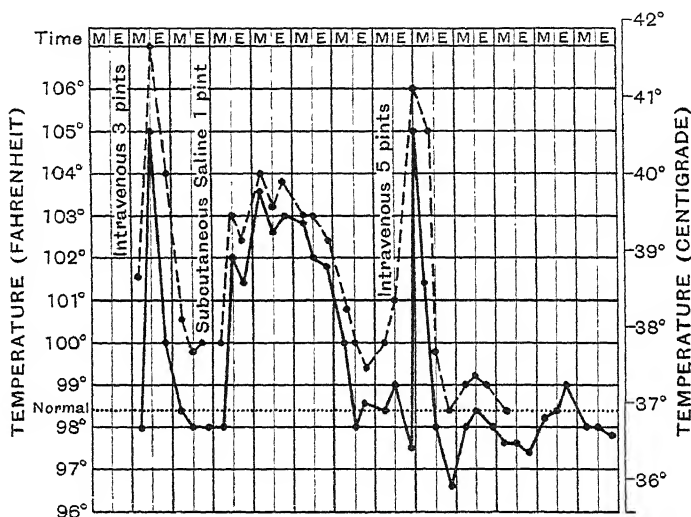


FIG. 19.—Hypertonic saline given intravenously at temperature of 36° C. in patient with high rectal temperature on admission, followed by temporary hyperpyrexia and secondary rise next day. A second intravenous injection was given for relapse on the third day. The dotted line represents rectal temperature. (From the Author's *Bowel Diseases in the Tropics*)

requisite amount of sodium bicarbonate is added after being sterilized in an autoclave as it should not be boiled in solution.

The temperature of the solution used in any given case depends on the patient's rectal temperature; if the latter is between 97° and 101° F., as in about 60 per cent of cases, the fluid in the flask should be at normal blood heat, and only in cases with a rectal temperature not above 97° should it be warmed to 102° to 104° F. In patients with rectal temperatures of 102° F. and above there is a danger of hyperpyrexia during the reaction following the saline transfusion (see Fig. 19), so it should be given at room temperature of the tropics (about 80° F.). Since this rule was made no fatal hyperpyrexial complication was seen in some 1,500 cases, whereas previously fatalities had occasionally been due to that cause. The quantity of the solutions used depends on the specific gravity of the blood, three pints being run in whenever it rises to between 1063 and 1064, and four to six pints for readings

*Quantity
of fluids
injected*

of 1065 to 1070 and above. A patient weighing 17 stone was given seven pints at one time with very good immediate effects. In all saline transfusions during the stage of copious evacuations one pint of the alkaline solution is given mixed with the required remaining quantity of

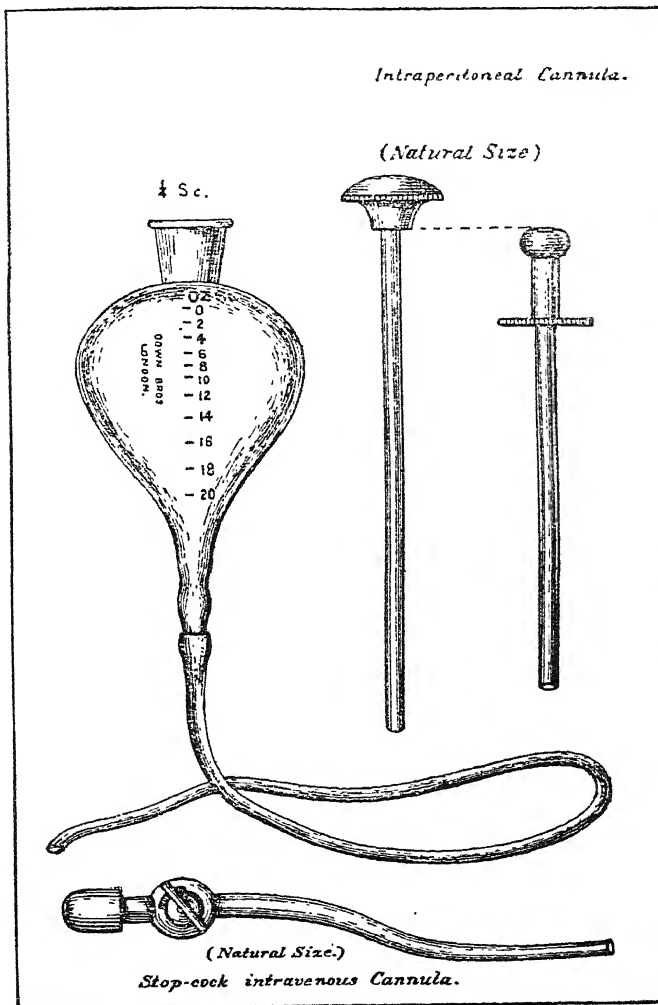


FIG. 20.—Instruments for intravenous injection
(From the Author's *Bowel Diseases in the Tropics*)

the hypertonic solution. Thus, if a total of four pints is necessary, one pint of the alkaline solution and three of the hypertonic solution will be used.

On account of the collapse of the veins and the frequent restlessness of the patient it is generally advisable to make a short incision, at (preferably) the elbow, over the median basilic vein; this should be

*Method and
rate of
transfusion*

carefully separated from surrounding connective tissues, the lower end of the exposed portion ligatured, and a ligature looped twice loosely around the upper end so that it can be tightened to hold the cannula in position without tying a knot. The anterior wall of the vein is now incised just below a portion held by a forceps, to allow insertion of the cannula which should have a stopcock to regulate the rate of flow. The flask should have a narrow neck and be graduated to show each two fluid ounces, as in that made for the writer by Down Bros. (see Fig. 20). The neck should be plugged with cotton wool and the solution sterilized. The rate of flow is regulated by turning on the stopcock after inserting the cannula into a vein, timing the flow of each two fluid ounces, and adjusting the stopcock to admit two fluid ounces in half a minute; this is equal to one pint in five minutes. After a good pulse has returned at the wrist, if any signs of oppression arise in the chest, the rate of flow should be reduced to one or two fluid ounces per minute for the remaining quantity. The flow should be rapid at first because in some cases a rigor may occur with great slowing of the inflow of the saline, but at the rate advised sufficient can nearly always be administered. The difficulty can also be overcome (L. M. Chatterjee) by giving an injection of 1 c.c. of pituitary (posterior lobe) extract. The great relief afforded by the saline is shown by a restless patient often going to sleep before the procedure is completed; an anaesthetic is not required for this minor operation. The cannula is now withdrawn from the vein and the looped ligature tightened to close the vessel without tying a knot and a suture applied, which the patient usually feels much more than the incision to open the vein. This will allow a further transfusion to be made through the same vein if required within twenty-four hours, as is so often the case, for on removing the suture the looped ligature can be easily loosened and the cannula re-inserted. In patients who are not collapsed or restless, but in whom a rise in the specific gravity of the blood indicates salines, a large vein at the elbow can sometimes be punctured by the transfusion needle, after a nick has been made in the skin, without exposure of the vein.

*Repetition of
intravenous
salines*

As often as the specific gravity of the blood rises to 1063 or above, or the blood-pressure falls to 70 mm., the above treatment should be repeated, and estimations of these data should be made at least every morning and evening, and also whenever the patient's condition becomes less satisfactory. The reduction in the death-rate in the Calcutta series to under 15 per cent occurred in the year that the largest number of saline injections per patient was given, and in a very severe attack in a European with repeated collapse 31 pints of salines were run into his veins in the course of four days with ultimate recovery.

*Other
methods of
replacing the
lost fluid*

Hypertonic salines, one pint at a time, may be injected intramuscularly into the thigh muscles, or subcutaneously into the axilla, or under the breast in females, with strict antiseptic precautions so as to prevent

suppuration, which is favoured by the debility of the patient: open containers should not be used. This form of injection is mainly indicated in very young children with small veins, although even in infants the internal saphenous vein in the thigh or at the ankle can be used with the aid of the fine glass cannulas used by physiologists for blood-pressure observations in small animals. Intraperitoneal saline injections, also used by the writer and others in children with cholera, are not so safe. The alkaline solution should not be injected subcutaneously.

Rectal saline in half-pint quantities of the alkaline solution every two hours should also be given slowly in all patients, as some of it will be absorbed and help to make good the loss of fluid and reduce the number of intravenous saline injections required. Continuous rectal salines by Murphy's drop method have been used with advantage. *Rectal saline*

Barley water may be given freely by the mouth even in cases attended by vomiting, for some will be absorbed and help to relieve the great thirst. Kaolin may be added to it as described later. *Fluids orally*

The older literature on cholera contains some remarkable examples of the inertness during the disease of enormous doses of such active drugs as opium, belladonna, and even croton oil; this indicates that there is little or no absorption of drugs through the damaged mucous membrane; the oral administration of drugs with a view to their absorption is therefore vain. In the middle of last century George Johnson of London advised purging cholera patients with castor oil, but this proved disastrous when tried in India by his pupil, Kenneth Macleod, and also recently in China at Harbin. Johnson was, however, at least right with regard to the prohibition of all direct attempts to check the diarrhoea in the acute stages, for it can only result in the increased absorption of toxins from the bowel. These toxins are albuminous and, like those of snake venoms, were proved by the writer's animal experiments to be readily oxidized into non-toxic substances by the action of small quantities of permanganates; he gave orally large doses of potassium permanganate, powdered and mixed with a little kaolin, made into pills with the aid of soft paraffin, and coated with salol and sandarac varnish or keratin to prevent them from being dissolved in the stomach; alternatively the enteric coated pills of Parke Davis & Co. may be used. The drug is slowly dissolved out of these in the small bowel without producing irritation. *Medicinal treatment*
Permanganates

All cholera cases should be given two pills of potassium permanganate, 2 grains in each, every quarter of an hour for the first two hours and then every half-hour throughout the acute stages of cholera (not only after the collapse stage is over as advised in the valuable book on cholera in China by Wu Lien-Teh). As much as 100 grains are often given during the course of a case, and good results were also obtained in China from total doses averaging 70 grains and sometimes amounting to more than 200 grains. Potassium permanganate pills have now taken the place formerly occupied by opium in the treatment of cholera in India and elsewhere, and even under the unfavourable conditions in *Dosage of potassium permanganate*

villages without hospitals or facilities for intravenous salines, the mortality in the Bombay Presidency was reduced from 51·74 per cent in 11,599 cases without them, to 35·57 per cent in 4,574 cases treated with permanganates.

Kaolin

Kaolin orally, as advised by R. R. Walker, is also of value on account of its power of absorbing toxins in the bowel. It can be given as one part of kaolin with 2 parts of water, well stirred, or in the form of a porridge in 3 ounce doses every half-hour until vomiting and diarrhoea cease. In China S. Braafldt reported good results from the use of a suspension of $1\frac{1}{2}$ pounds of kaolin in one quart of water in similar doses. A 2 per cent solution of sodium chloride orally was recommended by Wu Lien-Teh for vomiting, for which ice to suck, or drop doses of tincture of iodine, may also be of use.

Atropine

Injections of atropine sulphate, $\frac{1}{120}$ grain, morning and evening, during the collapse stage only, to lessen shock, as advised by Lauder Brunton, was also shown by a trial in alternate cases by the writer to be of value in reducing the death-rate.

Opium

Before these methods of treatment were established, the oral administration of opium and dilute sulphuric acid to check the diarrhoea were commonly used in India. Wall (1893) recognized that drugs were not absorbed from the bowel during collapse and logically gave morphine subcutaneously; at a time when no effective treatment was available, this no doubt helped to relieve the sufferings of the patients, especially from cramps. In view of the great variations in the case-mortality at the beginning and the end of a cholera season or epidemic already described it is necessary, in order to test the value of opium or other drug treatment, to give it in addition to the now established hypertonic-alkaline-permanganate treatment, either in alternate cases in order to have an equal number of controls, or throughout a year in places with known death-rates. On testing the value of morphine subcutaneously in alternate cases the case-mortality was nearly twice, and the incidence of uraemia seven times, as great as among those not so treated; the harmful effect was thus very evident. This is in accordance with the China experience already mentioned of the bad prognosis in opium-eaters attacked with cholera.

Mineral acids

Dilute mineral acids were similarly tested in alternate cases and the results were distinctly unfavourable, especially in increasing the frequency of fatal uraemia, doubtless due to the decrease in the alkalinity of the blood by the acids. They were also tried extensively without success in the Hamburg outbreak in 1892 and should be avoided in cholera.

Intestinal antiseptics including essential oils

The establishment of the delicate cholera vibrio as the cause of Asiatic cholera naturally led to the advocacy of various intestinal antiseptics, but their complete failure in carefully controlled trials to arrest the disease is easily understood now that it is known that the serious symptoms in the acute stage are largely due to the absorption of endotoxins set free by the breaking up of myriads of the vibrios in

the bowel. The most recent attempt in this direction was made when Sealy in India revived the use of the largely discarded Indian medical stores 'pro-diarrhoea' mixture containing 28 per cent of the essential oils of cajuput, aniseed, and juniper in equal parts, with about 22 per cent of aromatic sulphuric acid and spirit of ether 50 per cent given in 12 to 15 minim doses every half-hour, and both he and J. W. Tomb claimed that in the early stage it may cut short the disease. Sealy, however, did not suggest that the mixture was of much value in advanced, collapsed, and toxæmic cases, and Tomb, while admitting the loss of 72 per cent of collapsed cases in one series, disputed the value of the hypertonic treatment which saves 70 per cent of collapsed cases. Unfortunately no controlled test in alternate cases appears to have been made. A. Cannon in China reported good results from the treatment; Bharati in India, on the other hand, recorded a case-mortality of 50 per cent with the use of the essential oils, but only 16.6 per cent when permanganate pills were given in addition to the oils; in Burma, Dawson obtained the same death-rate on combining the essential oils with Rogers's treatment as the latter had got without the oils, and careful trials of the oils in Calcutta hospitals in all stages of the disease under conditions very favourable for observation of the cases failed to show the slightest benefit from the oils, the value of which has never been conclusively demonstrated by controlled tests.

Alcohol should be avoided during the acute stage, for even if the old view that it is a direct cardiac stimulant were correct, it would be useless because the circulatory failure is due to loss of fluid from the blood. Moreover, its vasodilator effect is actively injurious in cholera. *Alcohol*

The precise value of bacteriophage prophylaxis and treatment, at first sight a very promising remedy, is also still open to question owing to the very contradictory reports on its use. Theoretically a bacteriophage that can destroy nearly all the cholera vibrios in a case of cholera, as claimed by F. d'Herelle and R. H. Malone, appears to be the ideal prophylactic and curative remedy, apart from any possibility of increased absorption into the system of the endotoxins set free by the breaking up of the vibrios; and in cases treated before the onset of dangerous collapse its value should be demonstrable in a convincing manner. Unfortunately in practice the matter is far less simple, for I. Asheshov found it necessary to prepare recent cultures of A, B, and C types, from the oral use of which he claimed very good results. In Assam, Morison employed no fewer than 64 combinations of bacteria and phages in each brew with weekly additions of freshly procured phages, and he reported a reduced incidence of cholera over a period of five years in an area in which these combinations of phages were added to water supplies, as compared with a control area in another district. In Calcutta Pasricha and de Monte found that phages increased in the water supplies with the decrease of cholera in the late hot season, but they were also lowest with the least cholera during the rains. On the other hand, J. D. Graham (1930) reported that search *Bacteriophage treatment*

for bacteriophages in well-waters before, during, and after cholera epidemics had been fruitless. J. Taylor in Burma concluded that bacteriophage is not an essential agent in recovery, and that a phage capable of lysing vibrios isolated from a case did not influence the progress of cholera cases when administered orally. The use of bacteriophage in both treatment and prophylaxis is evidently far less simple than had at first been hoped, and W. F. Harvey from a careful review of the whole literature in 1933 came to the conclusion that its value was still unproved.

Since Harvey reviewed the literature on the use of bacteriophage, Pasricha, de Monte, and O'Flynn (1936) have recorded its carefully controlled trial, in addition to the routine treatment, in alternate patients and in separate wards during the epidemic season, in a series of 1,369 Calcutta hospital cases. The mortality was 13.5 per cent in the phage-treated cases against 16.6 per cent in the controls—a difference which they consider 'not statistically significant'. The results were, however, better in those passing agglutinable cholera vibrios, mostly seen during epidemic prevalence; the treatment therefore appears to be beneficial in some cases when the conditions permit fresh, active phage being used in addition to other treatment.

(2)—Treatment in the Stage of Reaction

*Control of
temperature*

The danger from excessive febrile reactions has already been pointed out, and nurses should be instructed to watch the temperature very closely during the stage of reaction following recovery from collapse, whether natural or after a saline transfusion. The onset of a dangerous rise of temperature can readily be detected by placing the back of the hand on the patient's chest, and at the slightest sign of restlessness the temperature of the patient should be taken. The common mistake of applying hot-water bottles to a collapsed cholera patient should be prohibited, for an attempt to draw any of the greatly diminished volume of blood from the vital centres to the body surface can only be harmful. Thus the writer has seen an unfortunate patient who, after having been revived from collapse by a saline transfusion, was smothered with hot-water bottles and developed a fatal hyperpyrexia. It is only when the rectal temperature is subnormal that warmth is indicated, but such cases are usually hopelessly toxic. If the surface temperature rises to over 103.5° F., or the rectal to over 104° F., steps should immediately be taken to reduce it by cold sponging, aided if necessary by a very cold enema.

*Re-establish-
ment of
urinary
excretion*

Continued deficiency of urinary excretion or complete suppression is the most frequent and grave complication during the reaction stage, due as already explained to either deficient blood-pressure or decreased alkalinity of the blood, often aided in a minor degree by continued concentration of blood as shown by a specific gravity over the normal level of 1056, but below 1063. It follows that regular morning and evening estimations of these data must be continued during the reaction

stage as a guide to treatment. All urine passed should be carefully recorded every twelve hours, and if it does not amount to about one pint within that period steps should be taken to ascertain the cause of the deficiency. In an adult patient a blood-pressure of at least 100 mm. is essential for full restoration of the urinary excretion during the reaction stage of cholera, and any reading below that point is an indication for the immediate intravenous transfusion of one pint of the alkaline saline solution, and any increase in the specific gravity of the blood above the normal indicates the same measure if the urinary excretion is materially deficient, and it can still safely be used even if the specific gravity of the blood is below normal in an anaemic or debilitated patient. The alkaline saline by the rectum should also be continued in quantities of half-a-pint every four hours, or by Murphy's drip method as long as the urine is deficient. Dry cupping over the loins morning and evening may also help to relieve renal congestion and to restart the kidneys working. In China Wu Lien-Teh advised 2 fluid ounces of 30 per cent pure glucose solution and 10 c.c. of 10 per cent calcium chloride solution intravenously in addition to the bicarbonate solution in the treatment of the acidosis present in these cases.

The most difficult condition to contend with is a blood-pressure persistently below 100 mm. in old feeble subjects, in whom the repeated alkaline salines fail to maintain the blood-pressure and renal action, although as much as 1,000 grains of sodium bicarbonate have been injected intravenously in such cases with eventual success. Injections of pituitary (posterior lobe) extract are of great value here, but the action of adrenaline is too transient, and this drug may be dangerous by inducing too rapid a temporary rise in blood-pressure for the weak heart to withstand. Such diuretics as caffeine and strophanthin may also assist, the latter being said to dilate the renal vessels while raising the general blood-pressure. Ephedrine has also been used for the same purpose in China.

*Treatment
of low blood-
pressure*

Barley water, rice water, or albumin water, to which kaolin may be added as already described, should be given freely during and after the stage of copious evacuations, even if vomiting is present, for much of it may be absorbed and help to relieve the terrible thirst. In strong and otherwise healthy subjects nothing else need be given for no food is likely to be absorbed through the damaged mucous membrane during the acute stages of the disease, and it is surprising how well even two or more days of practical starvation is borne. It is otherwise with feeble, very young, or elderly patients, in whom 2 per cent of glucose may be added to the intravenous and rectal salines to conserve the patient's strength. In the later stages great caution is necessary in recommencing feeding of the patient for fear of inducing a recurrence of the diarrhoea. Farinaceous foods, such as arrow-root and cornflour, together with milk whey, may first be given during the commencement of convalescence, and soups may be added, provided adequate urinary excretion

Diet

has been restored. Meat extracts, diluted milk, and eggs may gradually be added.

Convalescence is surprisingly rapid after an attack of cholera, but in all severe cases the recumbent position should be maintained for several days for fear of sudden fatal cardiac failure. In the serious toxic form of pneumonic complication ammonium carbonate orally in full doses appears to be of value. When the facilities exist bacteriological examinations of the stools, to determine the disappearance of the cholera vibrios, is advisable before the discharge of the patient.

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CHOLERA INFANTUM

See DIARRHOEA IN INFANCY AND CHILDHOOD

CHOLESTEATOMA

See BRAIN TUMOUR, Vol. II, p. 625; *and* EAR DISEASES

CHONDRODERMATITIS

See SKIN TUMOURS

CHONDRODYSTROPHIA FOETALIS

See ACHONDROPLASIA, Vol. I, p. 135

CHONDROMA AND CHONDRO-SARCOMA

See BONE DISEASES, Vol. II, p. 582

CHORDEE

See GONORRHOEA

CHORDOMA

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Reference may also be made to the following title:

COCCYX DISEASES

1.-DEFINITION AND AETIOLOGY

236.] Chordomas are rare malignant tumours along the course of the embryonic notochord. Small innocent tumours growing from notochordal remnants are by no means uncommon; they are discovered unexpectedly at routine post-mortem examinations, and consist of extremely soft gelatinous tumours connected with the bone in the region of the clivus or, less commonly, in the sacro-coccygeal region. These innocent tumours were first described by Virchow under the name 'ecchondrosis physaliphora speno-occipitalis'. Malignant chordomas, on the other hand, are clinically rare. Except for the fact that these tumours arise from embryonic cells representing the remains of the notochord, there is nothing to explain their origin.

Site

Analysis of the recorded cases shows that approximately 60 per cent occur in the region of the speno-occipital synchondrosis, about a third occur in the sacro-coccygeal region, and tumours have occasionally been reported from the occipital region, dorsal spine, lumbar spine, and mandible. The majority occur in men and women of middle age, though

the condition has been found at birth, and in patients of over seventy. *Age incidence*
 The average age in spheno-occipital cases is thirty-five years, in sacro-coccygeal cases fifty years. Males are affected more commonly than females in the proportion of two to one. *Sex incidence*

2.—ANATOMY AND MORBID ANATOMY

The notochord is an entodermal structure produced by an invagination of cells in the mid-line of the roof of the enteron, on the ventral aspect of the primitive neural tube, and is the axis around which the vertebrae are developed. At first the cells composing the notochord form a solid column, which is later converted into a tube by degeneration of the central cells. Eventually the cells degenerate along the greater part of the course of the notochord. In the adult, this course is indicated by a line passing from the clivus of the basi-sphenoid and the basi-occiput, through the apical ligament of the dens (the odontoid process), and thence through the bodies of the vertebrae and the nucleus pulposus of the intervertebral discs. *Origin of notochord*

The histological picture shows great variations and is in accord with the three above-mentioned developmental stages of the notochord; thus the cells may be arranged in solid columns, in alveoli, or in scattered masses. The most characteristic feature is the mucoid degeneration in the cells, so that the tumour may be confused histologically with the mucoid type of the mixed salivary tumour, or with mucoid degeneration in a carcinoma. Glycogen granules have also been demonstrated in some cases. The nuclei are but slightly hyperchromic; in some sections heteromorphism and mitosis are moderately well marked. The character of the cells corresponds with the clinical course of the disease; they are of low-grade malignancy. *Morbidity anatomy*

3.—CLINICAL PICTURE AND DIAGNOSIS

(1)—Spheno-Occipital Tumours

The tumours arising in the region of the spheno-occipital synchondrosis may present clinical features depending on increased intracranial pressure, involvement of cranial nerves, and infiltration of the basi-sphenoid and basi-occiput. In other cases involvement of the orbit, the sphenoidal sinuses, or the nasopharynx may cause early symptoms. The precise site of origin and direction of spread determine the dominating features in the symptomatology. *Symptoms*

As may be expected, differential diagnosis is often difficult and must be made in some cases from tumours of the hypophysis (though symptoms of pituitary dysfunction are uncommon), tumours of the cerebellum, medulla, or pons, and growths arising in the orbit or in the mucous lining of one of the accessory sinuses. Radiography is often of diagnostic assistance, since infiltration and destruction of bone is such *Differential diagnosis*

a constant feature of the lesion; encephalography, by means of air or lipiodol, promises to be of even greater help.



FIG. 21.—Chordoma removed from sacral region of man aged 49. No recurrence of the tumour after three years. $\times \frac{1}{2}$

(Royal College of Surgeons Museum, Specimen 1543·1)

(2)—Sacro-Coccygeal Tumours

Symptoms

Sacro-coccygeal chordomas may present symptoms of an external tumour growing from the posterior aspect of the sacrum or coccyx, or of a tumour growing from the anterior aspect of the bone (see Fig. 21). The anterior pelvic tumours may cause difficult or painful defaecation or even obstruction; there may be bladder symptoms, and sometimes retention of urine is the first symptom.

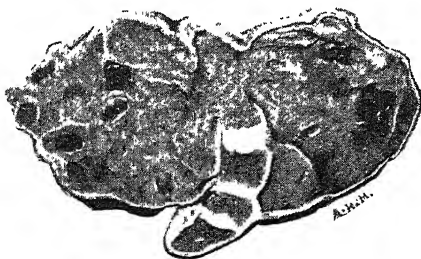


FIG. 22.—Chordoma removed from sacro-coccygeal region in man aged 49, showing median section through coccyx with adjacent portion of tumour, which consists of lobules of gelatinous material with scattered areas of haemorrhage. $\times \frac{1}{2}$

(Royal College of Surgeons Museum, Specimen 1543·2)

Alternatively the tumour may arise within the substance of the sacrum or coccyx, causing central erosion of the bone before infiltrating the surrounding soft tissues (see Fig. 22). The commonest symptom is local pain

in the neighbourhood of the tumour, but at a later stage there may be referred pain down the sciatic nerves, paralysis of the legs of the lower motor neurone type, and anaesthesia of legs and perineum. Incon-

tinence of faeces and urine occurs as the nervous mechanism of the rectum and the urinary bladder is destroyed by the growth.

4.—PROGNOSIS

In spheno-occipital cases the average duration of life is less than three years after diagnosis; in sacro-coccygeal cases the prognosis is somewhat better, the average duration of life being between six and seven years.

5.—TREATMENT

(1)—Basi-Sphenoid Tumours

Many cases have been treated surgically but with doubtful benefit in the majority. Owing to their situation, the surgery of access is difficult, and adequate exposure and extirpation of the tumour are frequently impossible. The direction of growth of the tumour determines the operative route, e.g. via a subtemporal osteoplastic craniotomy, via the orbit in the case of a growth destroying the eye, or by a nasal route in the case of involvement of the nasopharynx. While it is sometimes possible to remove the tumour apparently entire, local recurrence within a short time is the rule. Distant metastases are distinctly rare, as are very malignant types of tumour. Deep X-ray therapy and radium have both been tried but with doubtful benefit.

Surgery

*X-rays and
radium*

(2)—Sacro-Coccygeal Tumours

Excision of the tumour with a zone of normal tissue including part of the bony base, is indicated. The earlier the operation is performed the better the prognosis, although local recurrence, even after the lapse of some years, is common. If it is impossible to remove the tumour entire, partial extirpation has been practised in some cases with a certain degree of success, the remaining portion of tumour retrogressing in size. In the later stages palliative operations such as colostomy or suprapubic cystostomy may be necessary.

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CHOREA

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Reference may also be made to the following titles:

HEART RHEUMATIC FEVER

1.—DEFINITION

(*Synonyms*.—Sydenham's chorea; rheumatic chorea)

*Morbid
anatomy*

237.] Although choreiform movements may be called forth by other infective agents, it is generally acknowledged that there is a clinical entity called chorea which is most commonly associated with rheumatism. The disease is in fact by almost general consent regarded as cerebral rheumatism. Although the pathogenesis is not clear, the pathological findings in the brain are apparently very similar to those of the toxic encephalopathies. The lesions described in the relatively few fatal cases examined post mortem have been diffuse, chiefly in the basal ganglia but also affecting the cortex and other parts of the brain; the morbid changes include small-celled infiltration, vascular thrombosis, and degeneration in the ganglion cells. It is now generally assumed that rheumatism is a streptococcal disease and the absence of changes in the cerebrospinal fluid and the fact that with very few exceptions all cases of chorea get well without any sequelae in the nervous system suggest that the disease is due to toxæmia rather than to actual invasion by organisms.

2.—AETIOLOGY

The aetiological factors may be divided into (a) the rheumatic and (b) the predisposing or neuropathic. Chorea is commonest between the ages of five and fifteen, and the seasonal and class incidence, like that of age, is similar to that of rheumatism. In reviewing the histories of cases it is clear that while in a proportion (10 to 20 per cent) chorea is the sole manifestation, in the majority the chorea either precedes or follows a typical attack of rheumatism with cardiac and other symptoms. Sometimes, however, both conditions occur together during the primary illness.

*Incidence**Association
with
rheumatism*

It would seem that the more excitable the nervous system of a rheumatic child, the more likely is the child to develop chorea: this may explain why girls are affected two or three times as frequently as boys. Fatigue, excitement, and the strain of preparing for school examinations all appear to be important causes predisposing to the onset of an attack.

*Predisposing
factors*

3.—CLINICAL PICTURE

The onset may be acute but is usually insidious, and the prodromal stage may have been characterized by tonsillitis, lassitude, limb pains, or various nervous habits. In the earliest stage the child tends to drop things and walk unsteadily, and is fidgety and emotional; he may be difficult to manage and may fail to concentrate at lessons. Mild cases may never progress beyond this point: more commonly, however, there is a gradual accentuation of all symptoms until the picture becomes so striking as not to be easily confused with any other condition.

Onset

It should be realized that chorea is not merely a disease showing disordered movements, since in addition there are other important symptoms which complete the picture of the disease. The acute stage is characterized by a number of manifestations. These include: (a) mental and emotional changes, (b) irregular and involuntary movements, and (c) muscular weakness and hypotonus. Ataxy is usually noticeable in arms and legs and a degree of paresis is invariable, though often masked by the movements. Complete separation of these factors in a given case is not always possible.

Mentally the choreic child may be bright but more often is dull and shows signs of loss of memory. The face takes on a vacuous expression broken by frequent grimaces. The rapid change of emotions from laughter to tears is characteristic and is accompanied by a marked abruptness in the change of facial expression. Crying is easily evoked and is accompanied by howling and snorting noises. Some cases display great excitability and even delirium, and occasionally a true maniacal type (chorea insaniens) develops; this is usually associated with aphasia and the movements are apt to be of great intensity. Insomnia in a

*Mental
changes**Emotional
instability**Insomnia*

severe case may be troublesome and in the most restless cases may be extreme.

Character of movements

The movements are the most noticeable feature of the disease. Everyone is familiar with the irregular jerking, wriggling, and grimacing movements of a choreic child: they may affect the face, soft palate, tongue, trunk, limbs, and even the muscles of respiration. The movements vary in severity and are irregular and semi-purposive in character and do not show repetition of one particular movement. They are sudden and spasmodic. They cease during sleep but are increased by emotion and by voluntary movements. The speech is often hesitating and indistinct. Sometimes complete aphasia occurs and is evidence of a severe form, although this loss of speech is never permanent.

Changes in the muscles

The muscles are markedly atonic in most cases and sometimes advice is sought for weakness of an arm or leg in the child. The movements and weakness may be more pronounced on one side and may even seem limited to one half of the body but it is doubtful if a true hemichorea ever occurs; the facial movements at any rate are always bilateral. The pyramidal tracts must be relatively intact for the production of choreic movements, since the greater the degree of motor weakness present the less marked are the choreic movements. Sometimes, however, almost complete flaccidity of the trunk and limbs, so-called paralytic chorea, may develop, the movements almost disappearing except in the face. In such cases the child has a toxic aspect, the tongue is coated, there is stupor or coma, aphasia, and paralysis of sphincters resulting in incontinence.

Paralytic chorea

Reflexes

The chief feature of the reflexes is their variability. The knee-jerks may be diminished, but they usually have the pendular character typical of an atonic musculature. Not infrequently, however, a choreiform extension of the leg may coincide in time with the knee-jerk as elicited by percussion, and when this happens the resulting jerk has a prolonged 'hung-up' character that has long been familiar to clinicians and has given rise to the erroneous notion that the reflex response has a spasmodic or tonic character. Actually, this prolonged jerk is only an inconstant phenomenon due to the occasional coincidence in time of choreic and reflex movement. In paralytic cases the abdominal reflexes disappear.

Constitutional symptoms

The temperature may remain entirely normal or subnormal although sometimes there is an evening rise, but the fact that fever is absent cannot be taken to signify that infection is inactive. Although occasional rises of temperature may occur and be due to extraneous infection, the presence of fever usually denotes a rheumatic complication. During the course of a severe attack of chorea the temperature may mount and remain at 103° or 105° F. for several days, during which the movements may cease and the child may sink into coma.

The heart

The condition of the heart is important. Systolic bruits occur in 50 to 60 per cent of cases, although it has been estimated that only 20 to 30 per cent of these develop organic disease. A murmur may be present

at the onset, the result of previous rheumatism, or it may appear early or late in the attack of chorea, or it may develop quietly during late convalescence. the tendency being to develop an insidious form of mitral stenosis. It may be difficult to assess the significance of a systolic murmur, especially if there is no enlargement of the heart, but in other cases the presence of a diastolic as well as a systolic bruit, the development of pericarditis and of subcutaneous nodules leave no doubt as to the presence of heart disease.

Irregularity of the pulse is usually due to irregular respiration: rapidity *The pulse* of the pulse is often also of nervous origin but it is not always easy to discount active rheumatic infection as the cause.

4.—COURSE AND PROGNOSIS

The length of an attack is variable; mild cases recover in four weeks, cases of average severity take six to eight weeks to recover; severe cases may last four to five months. Relapses are frequent: as many as three *Relapses* or four attacks of chorea may occur in as many years and in these cases there is a danger that slow sclerosing endocarditis may develop.

Exacerbations of choreic movements during an attack may be due to an emotional disturbance but are mostly due to fresh infective activity.

Chorea itself is very rarely fatal but its presence is proof that the child is a rheumatic subject and therefore liable to develop other more dangerous forms of rheumatism. In fatal cases the child becomes exhausted by the movements and by the lack of nutrition. Aphasia denotes a severe attack: hyperpyrexia is rarely seen, but, when present, is an unfavourable symptom. The maniacal and paralytic cases always give rise to grave anxiety, and the outlook must always be serious when severe carditis is a complicating factor.

5.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

If the variations in the clinical manifestations which go to form the complete picture of the disorder are clearly appreciated, the diagnosis should not as a rule be in doubt. The chief difficulty arises in the earliest stages in distinguishing incipient chorea from the fidgetiness of a nervous child and from tics and habit-spasm and perhaps, for a short time only, in a mild case the distinction may not be easy to make. *Differential diagnosis*

Habit-spasm bears little resemblance to chorea. In habit-spasm there is repetition of clearly defined muscular contractions all of the same nature. Though the condition may spread and affect more than one muscle group, it never, as in chorea, involves the whole body. In doubtful cases various tests may be applied to confirm the diagnosis. Thus movements may be elicited by intently observing the child undress, when the futile and clumsy efforts made to undo buttons, for instance, will make clear *From habit-spasm*

the nature of the complaint. The movements of chorea are abrupt and unsustained and even the voluntary movements of the choreic patient show the abruptness; thus he protrudes the tongue sharply and as sharply withdraws it when told to do so. When asked to stretch out the arms, he holds the wrists flexed and the fingers hyperextended. Convincing positive evidence may also be forthcoming from testing speech and writing. The expression of the face, the character of the gait, and the type of knee-jerk can also be studied with advantage.

From other diseases of the brain

Once the chorea is declared, careful examination will differentiate it from the movements of cerebral diplegia or forms of encephalitis, and from the choreiform movements which can be a symptom of tumour of the mid-brain.

6.—TREATMENT

Prophylaxis

The recognition of the predisposing factors in the life of a child can do much to ward off an attack of chorea. The subjects are not only mentally very active, but are emotionally easily disturbed. Fright, worry, and excessive study, though not causes, are predisposing factors and much can be done by suitable adjustment of the life of the child to minimize their baneful effect. Quiet influences in the home and the elimination of excessive stimulation through the various sensory paths, i.e. from the eyes, ears, skin, and viscera can be accomplished to some extent. Thus advice regarding indigestion and eye-strain, and warning of the danger of unwise sun-bathing are often necessary. Since rheumatism is the most important factor, the necessary instructions regarding prevention of this should also be given. The possibility of the tonsils being a source of infection may require consideration. Lastly it should be emphasized that early treatment of the symptoms at the onset will in many cases cut short an attack or at least lessen its severity.

Treatment of active stages

In the treatment of chorea it is most necessary to view the disease in true perspective and to bear in mind that the chorea will pass without leaving any residual damage in the nervous tissues. Chief concern should be centred on the possible effect of the rheumatic infection on the heart, and, when advising measures to alleviate the chorea, it is important to guard against any which might seriously endanger the heart and circulation.

Treatment of acute stage

In the acute stage the one essential of successful treatment is absolute rest in bed and to ensure this the child must lie flat with only one pillow. If the movements are at all forcible care must be taken to see that the child does not injure himself by constant rubbing, for sores thus developed are slow in healing. As a rule it is a mistake for the patient to be nursed by a member of the family, for the discipline of a firm but sympathetic nurse is of the greatest possible value. Everything must be done for the child and he should not be allowed to feed himself. The environment should be as quiet as possible; but in a ward routine screening is not necessary since isolation and lack of interest are apt to have a

depressing effect on the child. It needs the exercise of judgement to decide how the child's mind should be occupied during the various stages of the disease.

For restlessness in the evening tepid sponging and warm packs are soothing. Hyperpyrexia is best treated by hydrotherapy and salicylates.

In the most severe forms feeding with a catheter may be necessary and in all cases the child must be fed during the acute phase: this may require great patience on the part of the nurse owing to the trying task of getting food into the mouth so that it is retained and swallowed; indeed it is often very difficult to make the child take sufficient food. In the early stages meals have often necessarily to be restricted to milk, eggs, and cereals, but later no special restrictions are called for and the diet should be liberal and appetizing.

Food and feeding

There is no special drug for chorea and it has never been proved that any drug used either in chorea or rheumatism is able to prevent the complication of carditis. It has been the practice in the past to push drugs to extremes, but this has been moderated since it has been realized that chorea tends to recover simply with rest.

Drugs

Sedatives are indicated in severe cases to prevent exhaustion, to promote physical and mental rest, and to secure sleep. For a child of seven years chloral hydrate, 7 to 10 grains three times a day (combined with bromide if desired), or chlorbutol 3 to 5 grains three times a day may be prescribed, provided that care is taken to watch for cumulative effects of these drugs, e.g. feeble pulse, cold hands and feet, and excessive drowsiness. Chlorbutol may also produce an erythematous rash and incontinence of urine. Other choices are methylsulphonal 5 grains three times a day, carbromal 5 to 10 grains three times a day, and for mild cases phenazone and potassium bromide, of each, 5 grains. For the maniacal cases resort must be made to injections of hyoscine hydrobromide $\frac{1}{800}$ grain, or of morphine sulphate.

Sedatives

Nirvanol, a drug related to the barbituric acid group, has been given a trial in recent years. It is prescribed for seven to ten days till a reaction is produced, the toxic symptoms being fever, morbilliform rash, eosinophilia, a rapid pulse, and headache. The use of this drug is not without risk since prolonged mental confusion, severe jaundice, and fatal nephritis have resulted; and since it neither prevents the recurrence of chorea nor the onset of other rheumatic manifestations it seems hardly justifiable to use it at all, much less as a routine.

It is the opinion of some authorities that antirheumatic drugs should be used and continued throughout the illness and even longer: if this view is adopted aspirin is perhaps best in chorea as it has an added sedative effect of its own; 5 to 10 grains may be given every four hours or less often and combined with methylsulphonal. If sodium salicylate is prescribed, and in the big doses commonly given for arthritis, i.e. 60 to 90 grains per day, it should be combined with double the amount of sodium bicarbonate. When the most active stage has subsided and while the child is still in bed a course of arsenic may

Anti-rheumatic drugs

be advisable. Other tonics, e.g. cod-liver oil and iron, are commonly prescribed in later convalescence.

*Treatment of
later stages*

The treatment of the later stages may prove tiresome. The acute symptoms may subside early but it may be long before slight residual movements disappear. It is three to four weeks on an average before the child is given a second pillow and then allowed to feed himself, to become more active, and take more interest in his surroundings. If the heart is affected, rest must be prolonged till there are no further signs of activity; this may entail six months' rest. In the absence of cardiac involvement six to ten weeks should see the child out of bed. When a slight residuum of movement, ataxy, and fidgetiness persists, it is sometimes the best policy to advise exercises and later to get the child up, since restraint in bed may even retard recovery.

*Con-
valescence*

Exercise

Massage and exercises are beneficial provided they are not started too early and that they stop short of fatigue: exercises and games hasten the recovery of control of voluntary movements. Re-education in this way is easily undertaken but requires some supervision or else movements are apt to be performed carelessly instead of accurately. Playing with bricks, sewing, knitting, crochet, jig-saw puzzles, and drawing are suitable kinds of occupation. Six months should be regarded as the minimum time before a child returns to ordinary life at school. This will entail in the average case three to four months' convalescence in the country either at home or at an institution. Occupation of some kind should be provided at the end of this period and if the child returns to

Chronic cases

school it is best to restrict attendance at first to half a day. Some few cases may pass into a chronic stage which may last one or two years, the movements varying in intensity but never quite disappearing. In such, care must be taken to prove the absence of chronic rheumatic toxæmia; occasionally removal of tonsils may arrest this state of affairs.

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CHOREA, HUNTINGTON'S

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Reference may also be made to the following title:

HEREDITY AND CONSTITUTION

1.—DEFINITION

(*Synonym.*—Chronic progressive chorea)

238.] This is an hereditary affection of the nervous system, characterized by a steadily progressive mental deterioration, commencing in middle-life, and associated with involuntary choreiform movements of the limbs.

2.—AETIOLOGY

Both males and females are liable to this affection. The age of onset is not always easy to determine owing to the insidiousness of the first symptoms, but it is probable that the disorder shows itself in most cases between the ages of thirty and forty. Bell's figures, based on 460 cases, give the mean age of onset as $35\cdot51 \pm 0\cdot39$. *Age and sex incidence*

It is certain that the Huntingtonian variety bears no relationship to the other clinical types of chorea, and that trauma, infection, and intoxication play no part in its pathogenesis.

*Inheritance
of the
disorder*

The most outstanding aspect of this disorder lies in its hereditary features. It appears that the determinants are transmitted as Mendelian dominants, the psychotic traits and the chorea being separately inheritable. The family-tree mirrors these genealogical factors so that the complete syndrome of Huntington's chorea may be traceable from one generation to another over a considerable period. It is believed that 'skipping' of a generation does not occur. The determinants are not sex-linked and maternal or paternal stocks may transmit the disorder (see Fig. 23). Since more than one determinant is at work, it follows that incomplete forms may appear among the families. Commonest of

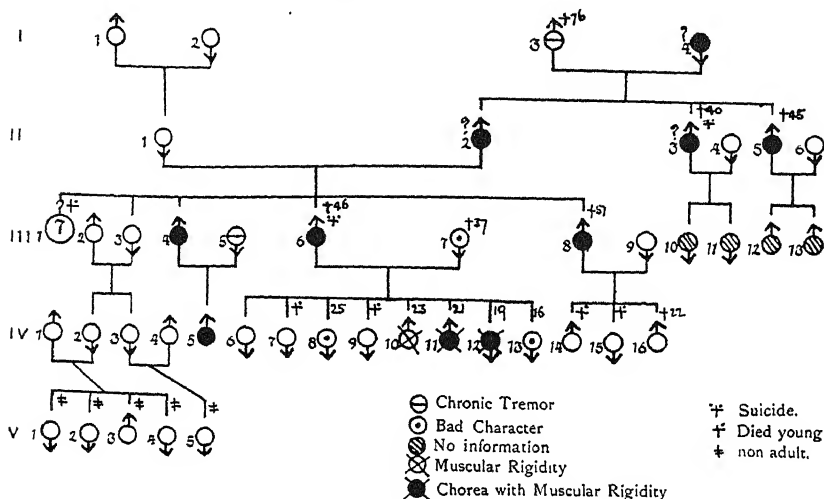


FIG. 23.—Pedigree in Freund's case of Huntington's chorea
(*Zeitschrift für die gesamte Neurologie und Psychiatrie*, 1925)

these are the instances of uncomplicated psychosis, the so-called cases of 'Huntington's chorea *sine chorea*'. Cases of chorea without dementia occur much less commonly.

Owing to the type of mental change commonly present, the family story is usually quoted as being punctuated by frequent instances of suicide, alcoholism, and delinquency. Bell, however, thinks that this feature has been over-emphasized in the text-books.

*Geographical
distribution*

Bound up with the problem of heredity is the question of the geographical incidence and distribution of the disease. Although there are few precise data available, we know that the disorder is very irregularly disseminated. Huntington's chorea is a rare affection in Great Britain; in 1934 there were no more than seventy-four cases under certificate in England and Wales (Critchley). Cases are commoner in some parts of the continent, e.g. Germany, but the greatest density of occurrence is in the U.S.A., especially in the States of Maine, Massachusetts, Connecticut, and New York.

It is from this American nucleus that the most exact information is forthcoming as to genealogy. Owing to the patient researches of such

writers as Davenport, Muncey, Vessie, and others, it is known that the considerable numbers of observed cases are descended from a relatively few original family stocks. As described by Vessie, and later elaborated by Critchley, the New England contingent of cases has largely emanated from a single family which emigrated from Bures, a village in East Anglia, in the year 1630. Although the seventeenth century records do not specifically mention that these earlier settlers were affected by a neuropathic disorder, the presumption is very strong, for we know that a significant number of this family were convicted of witchcraft and demoniacal possession.

The first clinical records of this disorder were made by C. O. Waters *Historical* in 1842 and by I. W. Lyon in 1863. Although it is true that this form of chorea was well known to certain medical men for over a century, credit for the first adequate description belongs to the paper written in 1872 by George Huntington, a general practitioner at Easthampton, Long Island. This doctor's father and grandfather had both practised in the same district and were cognisant of this curious familial disorder associated with the neighbourhood. Local superstition regarded the disease as a curse laid upon a remote ancestor who had mocked the sufferings of Christ upon the Cross. A variant of this tradition was that the victims were the descendants of those who had persecuted a certain Roger Williams, an eccentric revivalist parson who entered America in 1630.

3.—MORBID ANATOMY

The characteristic histological abnormality in the brain consists in:
(a) general shrinkage of the basal ganglia, with, in particular, a reduction in the number of small cells in the neo-striatum (putamen and caudate nucleus); (b) cortical and sub-cortical atrophy, most obvious in the frontal regions.

4.—CLINICAL PICTURE

The onset is always very gradual and diagnosis in the earliest stages *Onset* may be a matter of some difficulty. Mental and choreic symptoms usually appear simultaneously.

The former comprise first a progressive limitation of the intellectual horizon. As in most cases of steady psychical dissolution, the more subtle faculties of judgement, reflection, and constructive thought suffer early; later appear a slowness of cerebration with difficulty in concentration, lack of interest, forgetfulness, and retardation. With increasing disintegration more and more confusion is evident and gradually orientation becomes much impaired. Parallel with these mental symptoms changes in conduct and in mood appear. Increasing depression is common, associated with bouts of irascibility or uncontrolled anger, *Mental symptoms*

and with anti-social or indecent behaviour. The final picture is one of profound dementia and utter helplessness.

Choreic movements

Involuntary movements also make their appearance gradually. There is no constancy as to the segment of the body first affected, and the movements may begin in the face or trunk, and in either the proximal or distal portions of the limbs. Recognition of the nature of the movements is not at first easy, for the impression afforded is one of a diffuse fidgetiness rather than a chorea. Later, however, a twitching shock-like contraction of the trunk and limb muscles, together with the coarser semi-purposeful movements of the extremities, betrays their choreic nature.

Advanced cases

In advanced cases, the whole body is constantly distorted by involuntary movements, which cease only during deep sleep. The fantastic grimacing interferes considerably with articulation and, together with the disordered respiratory rhythm, renders the speech barely comprehensible.

Additional symptoms

Additional symptoms include muscular weakness and occasionally a rigidity of extrapyramidal type. It is noteworthy that the 'minor signs' so typical of Sydenham's chorea (hypotonus; hyperpronation of the forearm; the attitude of the outstretched hands; the characteristic protrusion of the tongue; pendular or sustained knee-jerks) are not demonstrable in cases of Huntington's chorea.

5.—PROGNOSIS

The disease is both chronic and incurable. It shows as a rule a steady but relentless march, necessitating institutional care for the majority of the victims. According to Bell the average duration of the disease in 204 collected cases was 13·72 years.

Death usually results from chronic exhaustion, with consequent lack of resistance to intercurrent disorders. Treatment is powerless to arrest this relentless progressive disease.

6.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Recognition of the involuntary movements as a chorea is easy in well-marked cases. Diagnosis has therefore to be made from the other types of chorea in the adult. When an adequate history is available giving details of an heredo-familial incidence, the diagnosis is established, for the Huntingtonian variety alone shows hereditary features. Only too often, however, no history whatever is forthcoming.

*Diagnosis from senile chorea
From apoplectic chorea*

Senile chorea is distinguishable by the very late age of onset, the absence of family history, and the lack of mental change.

Apoplectic chorea is usually quite sudden in onset. Usually the involuntary movements show a hemiplegic distribution, although both halves of the face are commonly affected. Rarely does the chorea

persist; either the hemichorea is followed by a hemiplegia within a few days or else death supervenes.

Chorea gravidarum is distinguishable by the fact of pregnancy, the frequent occurrence of rheumatic signs, and again by the absence of family history. Mental changes are often present, although differing in character from those obtaining in Huntington's chorea. *From chorea gravidarum*

Chorea and psychosis may appear as symptoms of an acute encephalitis, whether of the epidemic, syphilitic, or post-exanthematous variety. Such cases are recognizable by the short history, the fever, and the presence of inflammatory changes in the cerebrospinal fluid. *From other conditions*

It is possible that some doubt might exist as to the nature of the involuntary movements in an early case, and confusion may arise with the so-called 'double athetosis' (see Vol. II, p. 216). In this latter disorder there is a history dating back to childhood; mental defect rather than dementia is the psycho-pathological feature. The slow, writhing movements of the athetosis, coupled with the characteristic 'dystonia', are actually quite unlike the hyperkinesis of a chronic chorea. *From double athetosis*

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CHOROIDITIS

See BLINDNESS, Vol. II, p. 425; and UVEAL TRACT DISEASES

CHORIONEPITHELIOMA AND HYDATIDIFORM MOLE

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1. HYDATIDIFORM MOLE — — — —	216
2. CHORIONEPITHELIOMA — — — —	220

Reference may also be made to the following titles:

PLACENTA, DEVELOPMENT AND DISEASES
UTERUS DISEASES

1.—HYDATIDIFORM MOLE

239.] In a certain small proportion of pregnancies, less than 0·1 per cent, there occurs the remarkable change in the chorion known as hydatidiform degeneration. The process, although partly degenerative or retrogressive, is also in part proliferative, and there is not any dividing line between a benign vesicular mole and the most highly malignant forms of chorionepithelioma. Hydatidiform degeneration shows all grades from a slight localized change found casually on naked-eye or microscopic examination of the full-term placenta or more especially of earlier products of conception, to the well-known fully developed lesion in which the uterus is distended, sometimes far beyond the normal size for the stage of pregnancy, with masses and bunches of translucent, white currant-like vesicles. This more advanced and spectacular form of the disease, although often well represented on the shelves of the pathological museum, is rare compared with the slighter grades.

In the majority of cases recognized clinically a foetus cannot be found. In a minority of cases a foetus is recognizable and may be either perfectly normal, or under-developed for the period of pregnancy and malformed.

Histologically the normal chorionic villus consists of a core of *Histology* embryonic ('myxoid') connective tissue carrying the blood-vessels, and an ectodermal covering, the trophoblast, in which, up to about the end of the fourth month, two well-defined layers can be identified. The inner layer consists of small cubical cells with large vesicular nuclei and clear cytoplasm—the Langhans cells, the outer of a multinucleated syncytium with deeply-staining cytoplasm and numerous uniformly and deeply-staining nuclei irregularly distributed. After the fourth month the Langhans-cell layer undergoes a slow progressive atrophy, while the connective-tissue core becomes more fibrous and less myxoid, and at the same time more richly vascular. In the earlier months, large trophoblastic wandering cells may be seen invading the maternal tissues. It has also been shown, quite apart from any question of malignancy, that portions of detached syncytium may be carried as harmless emboli into the pulmonary capillaries of the mother, where they soon die and are absorbed.

In villi which have undergone hydatidiform degeneration two contrasting changes are seen. (1) The increase in size of the villus is due to swelling of the connective-tissue core, a result of advanced myxoid degeneration, with great increase in the water content ('oedema'). This is accompanied by diminished vascularity going on ultimately to complete absence of blood-vessels. The epithelium of these more degenerate villi tends to become thinned and atrophic and may be reduced to a syncytium only; finally it disappears, especially when necrosis supervenes. (2) In relation to the smaller and less degenerate vesicles, however, the epithelium may show signs of very active proliferation, with greatly increased cellularity. Solid sheets of Langhans cells with large syncytia intermingled may be seen attached to the tips of the vesicles or lying apparently free between them. The resemblance to the earlier stages of the foetal trophoblast is very close, and the question of malignancy may seriously arise. It is a good working rule that in cases of hydatidiform mole definite evidence of destructive invasion of the maternal tissues should be demonstrated before a diagnosis of malignancy is ventured.

Diagnosis of malignancy is made even more difficult by the fact that not infrequently syncytial masses may invade the myometrium, lying beneath the decidua basalis, in cases of normal pregnancy, and also in cases in which a placental polyp has for some time been retained in the uterus.

The aetiology of hydatidiform mole is obscure. A few cases of twin *Aetiology* pregnancy in which a normal ovum and a separate hydatidiform mole have developed together in the same uterus have been recorded. Such cases favour the inference that the condition is a primary disease of the ovum rather than a disease of the mother. A number of cases of recurrent molar pregnancy in the same patient have been recorded. The condition occurs at all ages in the child-bearing period. More than a third of all cases occur in patients over the age of forty. In about

1 case in 4 the condition occurs in a first pregnancy, but in a large series there is a high previous fertility.

*Clinical
picture*

The great majority of patients complain of some degree of abnormal uterine haemorrhage. In 10 per cent there is not any preceding period of amenorrhoea, but in 60 per cent there is a definite period of amenorrhoea, varying from a few days overdue up to three months, the remaining cases showing a period of amenorrhoea longer than three months. A few patients are free from uterine haemorrhage but complain of various symptoms, such as hyperemesis gravidarum, lower-abdominal pain or abdominal enlargement, or haemoptysis. More than a third of the cases show some evidence of pre-eclamptic toxæmia (hyperpiesis, albuminuria, or oedema), a condition almost unknown in the early months of a normal pregnancy. Most obstetric and gynaecological textbooks stress the frequency with which the uterus is larger than would correspond with the calculated duration of the pregnancy, whereas careful clinical observation of a consecutive series of cases showed that in about one-third the uterus was either of the size or smaller than would have been expected from the calculated period of amenorrhoea.

*Differential
diagnosis*

The majority of cases are diagnosed as some variety of abortion until the escape of the typical hydatidiform vesicles makes the diagnosis certain. In patients over the age of forty the condition is not infrequently mistaken for uterine fibromyomas or an ovarian tumour, as a brief period of amenorrhoea may be thought to be menopausal in origin. The presence of large multilocular lutein cysts of the ovaries (10 per cent of cases) may complicate the physical signs. These tumours tend to disappear spontaneously after the mole has been evacuated. An X-ray investigation by a skilled and experienced radiologist may be of considerable assistance in arriving at a diagnosis before any vesicles have escaped from the uterus. The absence of any X-ray evidence of a foetus when the uterus is clinically equal in size to or bigger than a sixteen-weeks pregnancy is very suggestive of a molar pregnancy; the alternative diagnosis would be hydramnios with a multiple or single pregnancy, the foetus being still too small to be visible radiologically.

Of recent years the pregnancy tests introduced by Zondek and Aschheim (mice) and by Friedman (rabbit) have proved of great value for the diagnosis of this condition before any escape of uterine contents has occurred. With the possible exception of a few hydatidiform moles which have become necrotic in utero, all patients with this abnormal type of pregnancy show an enormous increase in the output of gonadotropic hormone in the urine. This increase is rarely less than one-hundred times the amount found in normal pregnancy, and may be more than eight hundred times this amount. In a suspected case a specimen of urine passed first thing in the morning should be sent to a biological laboratory which undertakes such investigations, with a request for a quantitative Zondek-Aschheim investigation. The urine is injected into different mice, undiluted, and diluted 1 in 10, 1 in 25,

1 in 100, and 1 in 200. A positive result with urine diluted 1 in 200 is almost diagnostic of this condition. A false positive may occasionally occur in cases of uni-ovular twin pregnancy with hydramnios. An X-ray examination will help to distinguish between these conditions.

The prognosis of hydatidiform mole pregnancy is serious, as there is both an immediate and a remote mortality associated with the condition. Published mortality rates vary from 5 (Sande) to 16 per cent (De Lee). *Prognosis*

One of us (A. B.) has published a series of 72 consecutive cases with a mortality of only 1.4 per cent. This may have been fortuitous in so far as the series consisted of few cases, but it was probably to some extent the result of the methods of treatment adopted. The fatalities are usually due to: (i) very severe external bleeding; (ii) intra-peritoneal bleeding secondary to perforation of the uterus, either spontaneously by the mole or during its removal in cases in which the wall of the uterus is unusually thin and friable; (iii) severe puerperal sepsis, these cases being particularly liable to infection during the puerperium. The remote danger is the development of chorionepithelioma which occurs nearly always within six months of evacuation of the mole, and very rarely after an interval greater than twelve months.

Six of a consecutive series of 72 cases developed this complication (8.3 per cent). Other published figures show an incidence of chorionepithelioma after hydatidiform mole varying from 1 per cent (Novak) to 44 per cent (Pallosson and Violet). In none of these, however, is it clear that the author was dealing with a consecutive series.

The treatment should take into consideration the age of the patient and her general condition, particularly the degree of anaemia from previous haemorrhage and the chances of previous intra-uterine infection from examination and packing of the vagina. In cases in which a large part of the mole has already escaped spontaneously the uterus should be gently explored under an anaesthetic, particularly if the patient continues to lose excessively. If this is not done, fragments of mole are frequently retained and lead to further haemorrhage, greater risk of sepsis, and possibly a greater incidence of chorionepithelioma. Subsequently, if the cervix is still closed, and no part or only minute fragments of the mole have escaped, the treatment should vary with the age of the patient and the surgical conveniences available. If the patient is over forty, probably abdominal panhysterectomy is the treatment of election, as it minimizes the dangers of haemorrhage, sepsis, and subsequent development of chorionepithelioma. In younger patients the choice of treatment lies between abdominal hysterotomy and evacuation of the mole by an operation resembling a miniature classical Caesarean section, or the insertion of laminaria tents into the cervical canal with a glycerin pack in the vagina to keep them in position, and the subsequent stimulation of the onset of labour by castor oil, enemas, quinine, and injections of pituitary (posterior lobe) extract. *Treatment*

This latter conservative treatment is usually very satisfactory in cases which are threatening to abort spontaneously.

After-treatment

To minimize the danger of chorionepithelioma, and to facilitate very early diagnosis should it develop, it is usual to recommend exploration of the uterus and a diagnostic curettage in all cases six weeks and three months after the evacuation of the mole. Such a procedure is imperative if there is any persistent brown discharge or any irregular haemorrhage. The material obtained by curettage should be examined histologically by an experienced pathologist, as it is extremely difficult to distinguish between retained products of benign mole and true chorionepithelioma. In doubtful cases it is wiser to recommend complete removal of the uterus without delay than to temporize with such a high risk of malignancy. In some cases an early chorionepithelioma may develop in the wall of the uterus or vagina or even outside the genital tract, and its presence will not be suggested by any sanious discharge; it may even fail to be diagnosed by the curette. Fortunately, the pregnancy-urine tests are proving of considerable value in the diagnosis of early chorionepithelioma. They should not be used instead of but rather in conjunction with the routine exploration of the uterus.

If possible, quantitative Zondek-Aschheim tests should be done at monthly intervals during the first six months. If positive tests in considerable dilution (1 in 25 or over) persist for more than a month or increase in intensity at any time, the presence of a developing chorionepithelioma is very probable, even if not revealed by the diagnostic curettage. Exploratory laparotomy and panhysterectomy should be undertaken without delay. When such a persistence or sudden increase in the amount of gonadotropic hormone excreted in the urine occurs, the possibility of another normal intra-uterine pregnancy having supervened must be borne in mind, but such a pregnancy should not give a positive result in a dilution of 1 in 25.

2.—CHORIONEPITHELIOMA

240.] Chorionepithelioma or chorionic carcinoma is the form of malignant disease which originates from the foetal trophoblast or chorionic epithelium and is therefore a truly parasitic tumour, being derived from the tissues of another individual. Originally regarded as a sarcomatous growth of the uterine decidua (hence Sanger's term *deciduoma malignum*) it was claimed by Marchand in 1895 to be a derivative of the chorionic epithelium, and subsequent work has conclusively shown the correctness of this view. Almost invariably it bears some time-relation to pregnancy, following immediately or at a later date either a normal delivery, an abortion, or the passage of a hydatidiform mole. Cases have very occasionally been described occurring after the menopause or in the absence of a recent pregnancy, and it is suggested that the tumour has then originated from placental relics of a former pregnancy, which

have remained quiescent yet viable within the uterine wall for varying periods. Chorionepithelioma also occurs, although with extreme rarity, in relation to tubal and ovarian gestations. Occasionally it arises in the testis, the ovary (apart from gestation), the mediastinum, or elsewhere, either as part of an obviously teratomatous tumour or as an apparently unmixed growth which must be regarded none the less as teratomatous in origin.

Histologically the tumour, which is completely lacking in stroma and in blood-vessels, is composed of three varieties of cells in varying proportions: (1) multinucleated syncytial masses with deeply-staining cytoplasm, often much vacuolated, and corresponding to the syncytial layer of the chorionic epithelium; (2) small, well-defined polyhedral cells with clear cell-bodies and vesicular nuclei, corresponding to the Langhans layer; and (3) intermediate cells, of very variable size and shape, and apparently possessing specially invasive properties. *Histology*

Chorionepithelioma occurs more commonly as a complication of a hydatidiform mole than following any other form of normal or abnormal pregnancy. In a number of cases the only history available is of a recent miscarriage. Very frequently the products of conception have not been examined macroscopically or microscopically by a competent authority, so that in many of these cases a spontaneous abortion of a molar pregnancy may have occurred, although it is later impossible to prove it. However, in about 20 per cent of cases chorionepithelioma follows a full-term labour in which a normal living child has been born. In these cases too the placenta is rarely available for examination when a diagnosis of chorionepithelioma has been established, but it is known that other focal vesicular degeneration of groups of villi throughout an otherwise normal placenta may occur, so that one or more cotyledons may show complete vesicular degeneration, the remaining parts of the placenta being normal on macroscopic and microscopic examination. It is of course possible for chorionepithelioma to develop even if no part of the placenta shows hydatidiform mole degeneration. *Clinical features*

The most frequent symptom in chorionepithelioma is intermittent haemorrhage, *post partum* or *post abortum*, of varying degrees of severity, and this is often accompanied by progressive anaemia, wasting, pyrexia, and a putrid discharge from the uterus. If these manifestations should follow the passage of a hydatidiform mole, the likelihood of chorionepithelioma is greatly increased. In rare instances a rapidly progressive enlargement of the uterus is the chief symptom, and very rarely the clinical picture is dominated by the results of metastatic deposits, haemoptysis, enlargement of the liver, and thrombosed 'varices' of the vagina. *Haemorrhage*

Chorionepithelioma uteri usually presents itself as a bulky, friable, intensely haemorrhagic, maroon-coloured tumour projecting from the placental site and causing considerable enlargement of the whole organ. Even careful examination is likely to provoke further haemorrhage. On section the main mass appears to be largely composed of blood clot, *Tumour at placental site*

with a variable quantity of necrotic tissue and often a narrow marginal white zone where viable tissue is still present. Plate VIII, A shows a large fungating haemorrhagic chorionepithelioma at the fundus with extensive sloughing and a fistulous track leading through the whole thickness of the uterine wall to communicate with an abscess cavity lying between the fundus and the sigmoid colon. There is a small secondary deposit in the cervix, possibly from venous spread.

*Intramural
tumour*

In cases in which an early diagnosis has been made and the uterus removed without delay, an important and instructive variant of the usual anatomical picture is presented. This takes the form of a small intramural nodule, perhaps the size of a hazel nut. Plate VIII, B shows such a rounded, fairly circumscribed nodule of chorionepitheliomatous tissue at the fundus. A tumour so situated may escape even the curette, and operation may be delayed until there is definite enlargement of the uterus or secondary deposits have appeared. At the opposite end of the scale is the patient who does not seek advice until there is a stinking sloughing mass projecting from the uterus which may be mistaken for a sloughing myoma.

*Formation of
secondary
deposits*

In keeping with the behaviour of its normal prototype, the chorionic epithelium, this tumour early erodes and invades the uterine veins; hence the tendency to rapid and widespread dissemination by the bloodstream which is so striking in many cases (see Plate VIII, A). Two sites of secondary deposition are of particular importance because of their frequency: the vagina and the lungs. The vagina is involved by direct extension along the veins, giving rise to an appearance which may be mistaken for thrombosed varices, and the microscopic examination of an excised vaginal deposit has been known to give the first clue to the diagnosis.

In the vagina

It must be emphasized that intravenous extension to the vagina may occur apart from high-grade malignancy, i.e. in cases of invasive mole (chorio-adenoma destruens). The histological diagnosis in such a case is of the greatest importance. If actual villi with a mesoblastic core can be determined in the vaginal deposits, the prognosis is likely to be less grave and the case amenable to radical surgical treatment. The presence of sheets of rapidly-growing Langhans cells and the absence of recognizable villi are grave prognostic indications. As Ewing pointed out, the histological structure of the uterine growth is also of importance in this connexion.

*In lungs and
brain*

In the lungs, embolic blocking of small branches of the pulmonary artery has often been demonstrated *post mortem*. Occasionally a case may present for investigation with the symptoms and signs of a rapidly growing cerebral tumour. The presence of associated amenorrhoea or abnormal uterine haemorrhage or discharge should lead to quantitative Zondek-Aschheim tests on the urine. A positive result in high dilution will establish the nature of the tumour and thus prevent useless surgical intervention. In fatal cases secondary deposits are usually found in



A



B

Chorionepithelioma: A.—At fundus. B.—Intramural
(By courtesy of Dr. J. S. Faulds)

PLATE VIII

[To face p. 222

most of the highly vascular organs and tissues of the body. e.g. liver, spleen, kidney, breast. They are maroon coloured and haemorrhagic like the primary growth. *In other organs*

The diagnosis can be made with certainty by the microscope when the sections examined show invasion and permeation of normal tissues by trophoblastic elements in association with extravasations of blood and areas of necrosis. The evidence now available by means of quantitative Zondek-Aschheim tests on the urine is of the greatest possible help. It must, however, be remembered that the Zondek-Aschheim test may remain positive for a much longer period after a molar pregnancy (not infrequently several months) than after a normal pregnancy (rarely more than 2 to 3 weeks). The presence of a positive pregnancy test in a dilution of 1 in 25 or more, several weeks after a pregnancy, is so suggestive of a developing chorionepithelioma that immediate investigation and treatment are imperative if the patient is to have any chance of escaping general dissemination of the disease. The reappearance of a positive test after a previous test has been reported negative by a reliable authority calls for similar action. A negative pregnancy reaction should not at present be allowed to outweigh a histological report which either definitely diagnoses chorionepithelioma or does not definitely exclude it. *Diagnosis*

The prognosis after panhysterectomy is far more favourable than would be expected bearing in mind the very rapidly fatal course of the cases which disseminate, and it is well known that occasionally removal of the primary focus in the uterus does lead to spontaneous retrogression of definite clinical secondary deposits, especially those in the vaginal wall. The mechanism of spontaneous cure in secondary deposits in the lungs, by haemorrhage and necrosis, fibrosis and encapsulation, was clearly demonstrated by Teacher (1907-8). In apparently hopelessly advanced cases deep X-ray therapy and lead therapy are not without some possibility of success. The prognosis is usually far worse in cases following an ordinary miscarriage or a full-term labour, as in these the possibility of chorionepithelioma is not suspected nearly as early as in the cases following hydatidiform mole, where the danger of this occurrence as a complication is now becoming universally recognized. *Prognosis*

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CHOROID DISEASES

See BLINDNESS, Vol. II, p. 407; and UVEAL TRACT DISEASES

CHROMIDROSIS

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241.] Chromidrosis is an unusual condition in which the sweat is coloured, either red, orange, blue, green, or black. The axillae are the parts usually affected, but chromidrosis may be present in any other warm, hairy region. In the majority of cases of this rare affection the sweat is colourless when secreted, but subsequently becomes tinged owing to the growth in it of various chromogenic organisms. These organisms are usually of the streptothrix variety and they may sometimes be seen in zoogloal masses on the axillary hairs, forming concretions which themselves may be coloured. In another type the sweat becomes coloured as the result of dyes present in the clothing. 'Blue toes' from the wearing of cheap black-dyed stockings have been described.

When a colourless sweat is secreted, which at a later stage becomes coloured, the condition is called pseudo-chromidrosis. Much more rarely the sweat is coloured when secreted and this is 'true chromidrosis'. Occasionally this occurs as the result of the excretion of drugs by the sudoriparous glands, e.g. pink in the case of potassium iodide, green with copper salts, and blue with iron.

Rare cases have been met with in which a true coloured sweat is reported to be present, yet not related to the excretion of a drug. The colour is seen mainly on the face in the orbital regions, although cases have been reported of the condition on other parts of the body. The colour is usually blue or black and appears to be granular. The subjects of this curious condition are nearly always women—young, nervous, and of the hysterical type. It has been suggested that the colourless compound indican is present in the sweat and that this substance is oxidized into indigo either by some ferment or by simple exposure to the air; sufferers from this condition are usually constipated and show pronounced indicanuria. It is interesting to note that this type of case is still more rare now that hysteria among women is out of fashion.

The diagnosis of true chromidrosis should be made only with extreme caution and the question of imposition, i.e. the artificial production of the colouring on the skin by the patient himself—or more commonly herself—should be most carefully considered and if possible excluded before such a diagnosis is arrived at.

Haematidrosis or 'bloody sweat' may occasionally be met with, the blood having been extravasated into the coils and ducts. True instances

Description

Diagnosis

Haematidrosis

are a manifestation of purpura. But in former days, and especially on the Continent, 'bleeding stigmata' were reported as the result of powerful emotional disturbances in hysterical subjects.

Treatment

In chromidrosis due to colour-producing organisms regular washing of the affected parts is called for. It is advisable to remove the hairs by shaving and to wash the affected part with an antiseptic lotion such as the following:

Mercuric chloride	—	—	—	—	2 grains
Alcohol, 90 per cent	—	—	—	—	2 fl. ounces
Distilled water	—	—	—	—	to 8 fl. ounces

In cases not due to chromogenic bacteria inquiry should be made regarding the ingestion of drugs, especially potassium iodide.

The urine should be tested with Obermayer's reagent for the presence of indican, constipation must be dealt with, and intestinal antiseptics ordered. If the artificial production of the colour is suspected, careful observation is required, the patient being admitted to hospital under close but judicious control. Psychological investigation and therapy will probably be indicated.

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CHYLOCELE, CHYLOPERICARDIUM, CHYLOPERITONEUM, CHYLOTHORAX, ETC.

See LYMPHATIC VESSEL DISEASES

CIRRHOSIS

Of the kidney : *see* NEPHRITIS AND NEPHROSIS

Of the liver : *see* LIVER DISEASES

Of the lung : *see* LUNG DISEASES

CLAUDICATION, INTERMITTENT

See ARTERIAL DISEASE AND DEGENERATION, Vol. II, p. 48;
and CRAMP, Vol. III, p. 457

CLAUSTROPHOBIA

See PSYCHONEUROSES

CLEFT PALATE

See PALATE, CLEFT

CLIMACTERIC AND ITS DISORDERS

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SECTION II

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Reference may also be made to the following titles:

ARTHRITIS (SECTION MENOPAUSAL ARTHRITIS)
 SEX HORMONES

I.—THE CLIMACTERIC IN THE FEMALE

1.—INTRODUCTION

242.] The menopause, climacteric, and 'change of life' are terms variously used to describe the phenomena which characterize the termination of the reproductive period. In women the most obvious manifestation is the cessation of the menstrual cycle. On the average, this takes place between the ages of 45 and 50. In many instances it occurs before 45 and, in a few, it may take place even as early as the third decade of life. Such cases of premature menopause usually

depend upon some endocrinal disorder associated with hypofunction of the essential sex glands, namely, the anterior pituitary and ovary. In some instances the menopause is delayed beyond the age of 50, and on rare occasions, beyond 55. A menopause delayed to this extent generally implies the existence of some morbid factor, amongst the most common being fibromyomas of the uterus. The menopause tends to occur later in married than in single women, and in parous later than in nulliparous women. It is also said that women who reach puberty late tend to have an early menopause, and that those in whom menstruation commences unusually early tend to have a late cessation.

2.—STRUCTURAL CHANGES AT THE MENOPAUSE

The external organs of generation begin to atrophy, the mucous membrane of the vulva becoming pale and transparent. The vaginal opening becomes narrower and the whole vagina becomes narrower and shorter. These alterations generally occur slowly and they may not be evident for a considerable number of years. As a rule they manifest themselves more quickly in unmarried women and widows.

The uterus undergoes progressive atrophy, the cervix becoming shorter and smaller so that, in the old woman, it may be represented by nothing more than a dimple in the narrow vaginal vault. The uterine body undergoes progressive shrinkage in all its elements and there is a relative increase in the fibrous tissue as compared with the muscle, whilst the mucous membrane becomes thin as the result of atrophic changes in the stroma and glands. The glandular elements often show cystic dilatation.

The ovaries undergo fibrotic changes, their total volume shrinking, and there is a gradual disappearance of the epithelial elements. In the elderly women the organs are small with a markedly wrinkled surface. Sometimes, on the other hand, the follicles may, during the early stage of the post-menopausal changes, undergo cystic dilatation.

The anterior lobe of the pituitary is said to exhibit recognizable changes after the menopause, but these have not been accurately studied. There are apt to be alterations in the other endocrine glands. The thyroid, for example, may exhibit evidence either of hypofunction or of hyperfunction and, in some cases, there is said to be an excessive activation of the adrenals.

3.—CLINICAL PICTURE

The clinical manifestations of the menopause vary greatly in different women. In the normal case the menstrual periods cease abruptly and, apart from some minor disturbances of the vasomotor and nervous

systems, there may be little evidence of the change which has taken place. This happy issue is more likely to occur in women who have been in the enjoyment of good general and sexual health, and in those with a well-balanced and controlled nervous system. In many cases, instead of an abrupt arrest of the menstrual function, the periods may undergo a gradual diminution over an interval of several months before they ultimately cease, whilst, in other instances, there is an alternation between menstrual excess and menstrual reduction, or there may be a series of irregular intervals of amenorrhoea before the final cessation of the function. In not a few instances the menopause is punctuated by excessive and irregular uterine bleeding and, in view of the fact that this symptom may also denote the existence of gynaecological disease, women with such symptoms should be advised to consult a gynaecologist before the excessive loss is definitely attributed to the dysfunction that accompanies the menopause.

*Nervous and
vasomotor
features*

Amongst the other major manifestations of the climacteric, the most important involve the nervous and the vasomotor systems. Insomnia, irritability, dyspepsia, and mental depression are common. The vasomotor disturbances most commonly manifest themselves as sudden flushings affecting the whole body and associated sometimes with perspiration and chilliness. These flushings are apt to be most distressing and to add materially to the general nervous discomfort of the menopause. They arise without any apparent cause or on the occasion of even the slightest excitement and, when involving the exposed parts of the body, particularly the neck and face, they may create acute distress, and occasion much discomfort to a woman who often has to discharge social functions. In many instances palpitation, headache, and giddiness are present. These nervous and vasomotor phenomena are apt to be pronounced in highly-strung and emotional types.

There is a long-lived and widespread tradition that major nervous disorder is especially liable to occur at the menopause. It is true that there is an acceleration in the rate of increase of incidence of the major mental disorders between forty-five and fifty; but it is relatively a small increase and it is rash to regard this as exclusively, if indeed at all, as a side issue of the physical changes of the menopause. The reasons for doubting this view are based mainly on the observation that the rise in mental disorders among males at the same time of life is greater than among females, although in neither case is the rate of increase very pronounced (see Fig. 24). In males it is due largely to the effects of excessive use of alcohol, and syphilis (showing itself in general paralysis of the insane). But in general the causes of breakdown at this time of life in the male are not different in quality from those at any other time. In the female the serious types of breakdown at this time of life may be attributed much more plausibly to the changes in adjustment that are necessary than to any physical cause. In the unmarried who have hoped for marriage, or in the childless married woman, there is the difficulty of adjusting to the final frustration of

their hopes of a family. In the married, loss of physical attraction, the rivalry of the young, the departure of children from the home, and the like, are all factors of importance in different cases.

It might be argued that the data quoted above refer only to major mental illnesses, i.e. insanity, and that the figures of nervous breakdown in general do in fact increase very much; but there is evidence

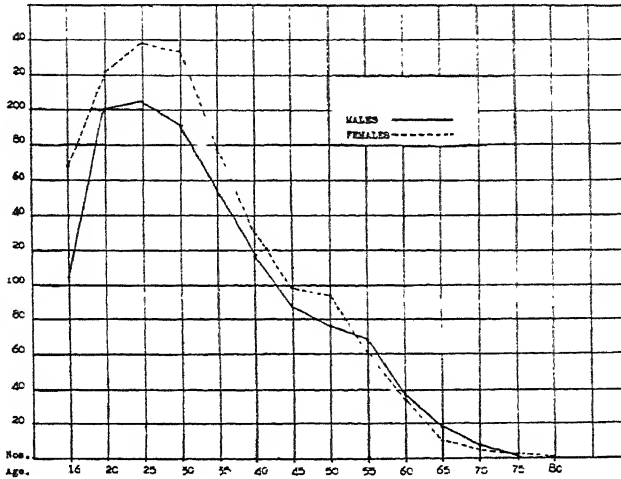


FIG. 24.—Showing proportionate incidence of miscellaneous nervous and mental diseases in age groups; 2,732 cases referred to the Department of Psychological Medicine, Guy's Hospital, 1926–35. (*British Journal of Physical Medicine*, 1935–36)

that the maximum incidence of such illness falls in both sexes much earlier than the involutional period of life.

Amongst other common manifestations of the climacteric may be mentioned the tendency to increasing obesity and so-called menopausal rheumatism. *Obesity and rheumatism*

Kraurosis and leukoplakia vulvae are local conditions which have their maximum incidence in the menopausal and post-menopausal periods.

4.—TREATMENT

Attention to general hygiene, the diet, sleep, and so forth, is important. In many instances the administration of simple sedatives, such as small and repeated doses of bromide, is useful—e.g. $7\frac{1}{2}$ grains six times in the 24 hours. *General treatment*

The most satisfactory method for the treatment of the severe reactions of the menopause consists in the administration of preparations containing the follicular hormone of the ovary, namely, oestrin. There are now a number of satisfactory preparations of this material on the market (for example, oestroform, sistomensin, menformon, *Hormone therapy*

theelin, progynon). In many instances the daily oral administration of one of these preparations is sufficient, but in pronounced cases it is an advantage to bring the patient immediately under the influence of the substance by means of large doses administered parenterally. In the presence of severe vasomotor, cardiac, or nervous symptoms the administration of 10,000 international units daily for a period of one week is usually sufficient to cut the attack short, after which the administration of the drug orally (e.g. two tablets of oestroform daily) may be sufficient to maintain the improvement. In many instances the treatment must be continued over a considerable number of months. In some cases of increasing obesity associated with lowering of the basal metabolic rate, the administration of small doses of thyroid extract may be of value.

*Treatment of
excessive
bleeding*

The excessive and irregular bleeding that may accompany the menopause may be so severe as to call for active treatment. In many cases all that is necessary is rest in bed, and this regime may be required at each menstrual period until the function is completely arrested. In cases of delayed menopause due to uterine fibromyomas, the same palliative measures carried out over a period of four or five months may be sufficient to control the symptoms and to protect the patient against need for any active operative interference. It is most important that in the presence of excessive and irregular bleeding the woman should be advised to consult a gynaecologist because, though this symptom, in the large proportion of cases, is capable of being explained in terms of the impending menopause, it should be remembered that cervical carcinoma has its maximum age incidence about this time of life and that its symptoms may be very similar.

For a discussion of kraurosis vulvae and leukoplakia vulvae see VULVA DISEASES.

II.—THE QUESTION OF A CLIMACTERIC IN THE MALE

*Sex hormones
and prostatic
enlargement*

243.] From the analogy of the female climacteric, and the rough correspondence between the menopause and the more gradual failure of male sexual activity, it has often been assumed that males pass through a critical period (climacterium virile), distinct from normal old age, and due to gonadal changes and endocrine imbalance. It has recently been suggested that prostatic enlargement, a definite morbid change, is part of the male climacteric and due to imbalance of the sex hormones. That all elderly males do not suffer from prostatic enlargement is not an invincible argument against this suggestion, for in females the menopause may occur without other symptoms. Experimentally prostatic hypertrophy has been produced by excess of oestrin (Burrows, 1935) and also by the excess of the male sex hormone androsten (Sevringhaus, 1934). But the urine of patients with prostatic hyperplasia

and carcinoma was found not to show much variation from the normal in its contents of prolans or oestrin-like compounds by Owen and Cutler, who concluded that though prostatic hyperplasia, benign or carcinomatous, may be due to long-continued imbalance of the sex hormones, this imbalance is not apparent from their observations.

From a purely verbal point of view, if the waning of sexual power in males, however prolonged and irregular this may be, is regarded as the change of life, the use of the term is logical.

The notion of a male climacteric was criticized by Sir Henry Halford in 1813 because it occurred so irregularly, between 50 and 75 years of age, and he stated: 'I will venture to question whether it be not, in truth, a *disease* rather than a mere declension of strength and decay of the natural powers'. He remarked that the climacteric disease sometimes, but much less often, occurred in women, and commonly followed some cause, most often a common cold, an attack of gout, a bout of intemperance, recent marriage, and 'above all, anxiety of mind and sorrow'. His argument that recovery showed that this hypothetical climacteric disease was not mere senility would, however, also be valid for the existence of a male climacteric. Marañón (1934) more than a century later arrived at a conclusion which, while endorsing Halford's general view that the supposed male climacteric is a disease, carries it further; namely, that the symptoms are always due to a morbid process, especially arteriosclerosis, in the ageing organism and are not specifically related to the sexual involution. According to Zondek (1935), however, changes in body and mind resembling those in women occur in men in the middle of the fifth or early in the sixth decade, especially mental instability and irritability and raised blood-pressure.

*Halford's
theory of
male
climacteric*

*Marañón's
theory*

*Zondek's
theory*

Life is a continuous change, first evolution and later involution; and about the age of 50 years, more than two-thirds through life's span, the processes of normal involution are well on their way, and the effects of past infections, toxæmias, injuries of various kinds, and inherent tendencies are accumulating. This is the period of life when the results of high-living and a raised blood-pressure, such as arteriosclerosis, chronic nephritis, and cardiac inadequacy, are likely to become obvious, and may when taken into account with waning sexual activity be optimistically explained as part of the male 'change of life'. No doubt this interpretation appeals to the lay mind, and is probably facilitated by the rather vague and common symptoms which have at one time or another been ascribed to the male climacteric, namely, atonic dyspepsia, flatulence, constipation, loss of appetite, debility, lassitude, headache and giddiness, rheumatic pains, drowsiness in the day and insomnia or disturbed sleep at night, mental torpidity, neurasthenia, the inferiority complex, and melancholia. These symptoms may be due to a number of causes, some of which, especially arteriosclerosis, have been mentioned above; other causes are an acute infection, such as influenza, followed by the slower convalescence characteristic of advancing years; hypothyroidism; chronic sepsis; dietetic and alcoholic excesses. In those

*Climacteric
and
senescence*

Symptoms

Treatment

of an unstable make-up the loss of sexual power may exert a psychological effect which will require treatment. In every case a careful search for the underlying factors must be undertaken, so that appropriate treatment can be given. It is useless to attempt to put the clock back and increase sexual activity by such means as aphrodisiacs, vasectomy, grafting of the gonads, or the administration of sex hormones. These may lead, partly by suggestion, to a temporary re-erotization, followed by a more rapid failure. In Warthin's words 'there is no rejuvenescence possible for the senile individual . . . the idea of physical rejuvenation is but a myth of ancient lineage disguised in quasi-scientific garments'.

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CLIMATE IN THE TREATMENT OF DISEASE

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Reference may also be made to the following title:

SANATORIUM TREATMENT

1.—METEOROLOGICAL FACTORS

244.] The amount of solar radiation reaching any part of the earth's surface (insolation) depends on: (1) its intensity; (2) the area of the intercepting surface and its inclination to the sun's rays; (3) the transparency of the atmosphere; and (4) the position of the earth in its orbit. With increasing latitude the angle of insolation becomes more and more oblique and there is a corresponding decrease in its intensity. With a homogeneous land surface, and an absence of both atmospheric and ocean currents, the distribution of temperature would depend solely on the latitude. Temperature is more uniform and more dependent on latitude in the oceanic parts of the globe than in the continental, but the isotherms, i.e. lines drawn on maps through all places having the same average temperature, do not by any means follow the parallels of latitude. The 50° F. and the 40° F. isothermal lines, for example, are directed somewhat northward in crossing the Atlantic. For this reason

the north-west Atlantic and the north-west of Europe are in January about 30° F. warmer than would be expected from their latitude. The isothermal lines are least irregular over wide expanses of ocean in the southern hemisphere, while the greatest deflections are seen over North America, the Atlantic, Europe, and Asia.

Solar radiation

The light that renders objects visible to the eye consists of wave lengths varying from about 0.4 to 0.8 μ , the first named corresponding with the violet and the latter with the red end of the spectrum; between the two are the other colours of the rainbow—indigo, blue, green, yellow, and orange. At the upper limit of the atmosphere the intensity of the violet is much greater than that of the red, and at high levels, above its lower and denser layers, sunshine is much richer in ultra-violet light than at sea level; but at the level of the ground the proportions are very different, because the shorter waves are more readily scattered by the atmosphere than those of greater length. When sunlight has to pass through vast depths of dust-laden atmosphere, as for example at sunset, the longer rays preponderate to such an extent that red is the characteristic colour of the setting sun. The long waves are practically without any chemical action on the skin. The shorter rays (the blue, violet, and ultra-violet) stimulate chemical activity in the skin (production of pigment), and the strength of this stimulus increases as the waves shorten. The pigmentation of the skin, thus induced, protects the surface of the body from the more active rays. It is therefore difficult to understand why it is considered healthy to expose the entire surface of the body to the direct rays of the sun for hours at a time when nature endeavours to mitigate its effects in the manner just indicated.

Effects on the body

Insolation is a therapeutic measure of considerable potency, and precautions regarding its employment are just as important as they are in other forms of active treatment.

Clothing

The effect of the selective absorption and heat-giving properties of short-wave radiation has an important bearing on the colour of clothing suitable for hot countries. Colours attributed to any object are due to the reflection by them of the light which falls on them. A white object scatters a large proportion of the rays whereas a dull colour absorbs them. Heat is much more readily absorbed by black cloth or lining than by white duck. Moreover, all solids at atmospheric temperature, independent of their colour, radiate heat (infra-red) rays which are absorbed equally by all substances. Clothing absorbs these long or infra-red rays and, if there were no short-wave radiation, it would tend to take the temperature of the surrounding air. It therefore follows that in the absence of direct daylight the colour of clothes is immaterial and that white-drill mess jackets are no cooler than those of any other texture or colour of the same weight.

Atmospheric radiation

Water vapour is the most important absorbent in the atmosphere; it takes up some of the solar radiation in the visible spectrum and much of the infra-red. If the absolute humidity of the atmosphere is high, as it often is in the tropics, the water vapour present acts as a 'black body'

and emits the full heat radiation of such a substance at its own temperature. As the temperature of the air rises and the amount of water vapour increases, the infra-red radiation from the ground and from the moisture in the air also increases, so much so that the intensity of the infra-red radiation derived from these sources approaches that of the sun itself.

Clouds have a very high reflecting power. Simpson pointed out that an increase in radiation from the sun would lead to an increase in the amount of cloud and therefore to an increase in the proportion of light and heat reflected by them—amounting in reality to an automatic control of the temperature of the globe. *Significance of clouds*

Terrestrial radiation consists of long-wave or infra-red radiation which is reflected by the water vapour which it meets quite close to the ground, so that the inward and outward flows balance each other. In addition to these there are short waves that can pass through water vapour to outer space, provided the air is clear and there are no clouds. In this case there is no compensatory inward radiation. Radiation of intermediate wave-lengths to which water vapour is semi-transparent also takes place. *Terrestrial radiation*

The quantity of water suspended in the atmosphere is strictly limited by the temperature of the air, and is one of the few constituents of the atmosphere which varies greatly from place to place. Absolute humidity is the mass of vapour expressed in grams per cubic metre of air, and is only important in relation to respiration, in that expired air is completely saturated with moisture; the same quantity of water therefore leaves the body at every breath no matter what the humidity of the atmosphere may be, but the quantity of water taken in at each breath does depend on the humidity of the air. The difference between the quantity of water taken in and that sent out has to be drawn from the water already in the body. At low temperatures the air can only hold very small quantities even when completely saturated. In cold climates, therefore, breathing involves the loss of large quantities of water, which no doubt explains the well-known thirst experienced by polar explorers. *Humidity*

Relative humidity is the ratio, expressed as a percentage, of the actual amount of water in a given volume of air, to the amount that would be present were the air saturated. The term really indicates the percentage of saturation. For the sake of brevity it is generally spoken of as 'the humidity'. *Relative humidity*

At climatological stations the humidity of the air is calculated with the aid of tables from the readings of the dry and wet bulb thermometer. Its chief importance lies in the fact that the rate of evaporation from the skin largely depends on it. Air at a temperature far above that of the body, if dry, does not cause a rise of temperature since loss of heat through evaporation of sweat is able to balance that gained by radiation and conduction as well as that produced in metabolism. Moist air, even when below body temperature, may not be able to remove as much heat

by radiation, conduction, and convection, as the body produces in metabolism, so that a rise of internal temperature must take place.

If, however, the air is kept in rapid motion so as to utilize its heat capacity and conductivity to the utmost, the balance may still be maintained. Should a rise of bodily temperature occur it is apt to be progressive, since metabolism and heat production are increased by the rise in temperature more than the rate of heat loss. It is not so much the actual temperature of the air, as the rate the skin can cool, that influences the sensation of comfort.

The kata-thermometer (Hill, Griffith, and Flack) is used for the direct measurement of the cooling power of the atmosphere for dry and wet objects. But as the human body has a partly moist surface, it cannot be compared with either a wet or dry body so that it is a little uncertain how these wet and dry readings should be combined.

Atmospheric pressure

The pressure of the atmosphere at any given place depends on the temperature of the air and the amount of moisture it contains. If aqueous vapour displaces dry air, the pressure is diminished, since, referred to hydrogen, the specific gravity of aqueous vapour is 9 while that of air is 14.4. When the pressure is high the concentration of oxygen is high, and when it is low there is a deficiency of oxygen. When ascending mountains or descending into mines the pressure may be halved or doubled, and correspondingly the quantity of oxygen.

Oxygen

Winds

As the vast majority of people neither ascend mountains nor descend into mines the proportions of oxygen present in the air in these situations is not of much general interest. Variations in barometric pressure, however, cause winds, and although a wind does not alter the physical characteristics of the air, it certainly affects the health and comfort of those exposed to it.

2.—ENVIRONMENTAL CONDITIONS

The skin as an adaptive organ

The human skin, regulated by an extremely intricate anatomical and functional mechanism, involving the blood, nervous system, and the hormones of the body, has developed an unusual sensitivity in registering environmental changes. Each passing atmospheric deviation is associated with alterations in all the physiological processes of the body, the result of prompt autonomic adaptation.

The atmospheric gases influence the chemistry of the blood and tissues, the state of the endocrine glands, the white cell count, the urine, and the acid-alkali balance. The major chemical changes thus originated do not come within the realm of consciousness so long as they remain within physiological limits. Clinical symptoms arise only if tissue areas are present which are unable to adapt themselves to alterations in the environment.

Reaction of body to cold

Exposure to cold, for example, involves vascular constriction, either general or local, which, by the impairment of the vascular bed, brings

about a relative anoxaemia. This causes the entrance into the blood-stream of metabolites produced under conditions of impaired tissue respiration. These products are usually acid and in their turn dilate the capillaries and arterioles and stimulate the tissue cells in general (Petersen). In this way periods of relative alkalosis are followed by periods of relative acidosis; there are alternations between high and low carbon dioxide content and between high and low cholesterol content, and similar variations are observed in the leucocyte count. As Petersen pointed out, these fluctuations are greatest and most abrupt in the storm tracks, and in certain regions of the country meteorological quiescence may at times lead to oxygen deficiency.

When the tissues are at rest less oxygen is required, and its deficiency in such circumstances is of little moment. With advancing age, owing to the lessened demand for oxygen, the blood-vessels tend to diminish in capacity and this leads eventually to a more permanent contraction and rigidity of their walls.

Every atmospheric disturbance is a stimulation for the individual, which, however, in the majority of instances is quite unnoticed. Sunshine and atmospheric quiescence engender a general laxity in the more robust on account of the absence of the needed stimulus. On the other hand, for the feeble and old, warmth and equability of climate are essential because the reactive powers of the body are deficient. If atmospheric disturbances are sufficiently frequent and intense, the stimulation they afford may be optimal; but if they occur too frequently the individual may become over-stimulated and fatigued. If the reactive powers are inadequate such stimulation may result in illness or even death.

*General
reactions to
environment
stimuli*

It is therefore possible to divide climates into protecting and stimulating or, in more common parlance, relaxing and bracing. A protective or relaxing climate allows the functions of life to be carried on with the least possible disturbance, and furthermore makes very little call on the adaptive resources of the patient. A stimulating or bracing climate has the opposite effect; it keeps the adaptive functions in a state of efficiency by constant exercise, promotes tissue change, and aids the rhythmic alterations in the physiology and chemistry of the body. The average weather conditions of any locality which fulfils these requirements depend on three factors: (i) its latitude, (ii) its position relative to oceans and continents, and (iii) its local geographical features. Upon these factors is based a classification of climates into (a) sea, (b) insular, and (c) continental of high, medium, and low altitudes, the respective characteristics of which together with their chief therapeutic indications are dealt with below.

*Classification
of climates*

(1)—Marine (Ocean) Climates

Marine (ocean) climates are characterized by the following features: *Temperature*
(1) Temperature is moderate; even in tropical latitudes at sea it rarely exceeds 85° F. (2) Temperature is equable because of the great amount of heat absorbed by the sea during the day. This is given back during

Humidity the night, thus preventing the drop in nocturnal temperature which would otherwise occur. (3) The relative humidity at sea is always tolerable and generally agreeable. Its mean is in the neighbourhood of 73 per cent of saturation. It is curious that the air at sea is frequently less moist than at some coastal resorts. (4) The atmosphere is relatively pure, and being free from other impurities, whatever force the winds may have, they are usually fresh and invigorating except in a following breeze when the heat may be overpowering. (5) The mean annual temperature of the surface of the ocean for some distance north and south of the equator is about 80° F. In the polar regions it is about 30° F. The seasonal range of temperature at the extremes of latitude is about 10 degrees, but in the regions between considerably greater. Owing to the great capacity for heat possessed by sea water the diurnal variation in surface temperature only amounts to 1° F. or even less.

Winds

Indications The indications for ocean climates are chronic laryngitis of the 'dry' form, especially if the patient can be induced to spend most of his time on deck and not in the ship's bar; recurrent catarrhal bronchitis in young and middle-aged subjects; convalescence from acute non-tuberculous chest affections; hay-fever during the time the offending pollen is being scattered; convalescence after operations; and post-influenzal debility, especially when accompanied by mental depression and insomnia. Cases of definite psychasthenia that are likely to derive benefit from an ocean voyage are comparatively few. Patients in need of psychological treatment should certainly not be sent on long journeys by land and sea. Only those suffering from fatigue states or from the result of faulty environment are likely to respond satisfactorily to climatic treatment; the latter, however, are liable to relapse on their return home if the exciting cause remains operative. Probably the best kind of voyage is in a large cargo steamer which carries a limited number of passengers.

(2)—Insular or Sea-Coast Climates

Temperature Insular or sea-coast climates resemble in most respects those met with on ocean voyages. Their characteristics are: (1) Moderate temperature; the charts published by the Meteorological Office show, so far as Great Britain is concerned, the mitigating effect of the sea on diurnal and nocturnal temperatures as compared with inland stations at about the same latitude. (2) Small variation between day and night temperatures; this is ensured by the moisture always present in sea air, which, acting as a screen, prevents rapid cooling of the ground such as is apt to occur when the air is dry and the sky cloudless. (3) Mean relative humidity very much the same as obtains at sea. (4) The presence of breezes; when the air over the land becomes heated by the sun's rays it expands and the pressure falls; as a result the air rises and is replaced by cooler air from the sea; this is the familiar sea breeze which increases in force as the day advances. After sunset the ground becomes cooler than the sea, which causes a flow of air in a contrary direction and this

Winds

constitutes the 'land' breeze lasting the greater part of the night. In parts of the coast where these currents of air are not operative in warm and cloudy weather, climatic conditions are apt to be very oppressive and relaxing. When the wind is blowing off the sea the air is pure and invigorating, but the same cannot always be said for a land breeze which may carry all manner of dust and contamination as well as being very hot and enervating.

One of the first questions asked about any marine resort is whether it is bracing or relaxing. The introduction of such terms as tonic and sedative seems to be superfluous as well as inaccurate.

*Bracing and
relaxing
sea-side
resorts*

Most coastal resorts have grown from fishing villages that were originally established near an estuary or small arm of the sea, which constituted a safe anchorage or landing place. Many have been built under the shelter of some promontory or cliff. The older parts of these towns are always practically on the sea-shore. As the population has grown to include those whose livelihood does not depend directly on the sea, the town has extended to more exposed parts. For this reason nearly every sea-side town can boast of two climates: (1) the extension of the old town in the form of under-cliff walks which are well sheltered from the prevailing winds, and where on most days invalids can sit and walk in comparative comfort; (2) the higher and newer parts of the town so exposed that there is usually as much wind as the ordinary mortal can wish for. From this it will be gathered that the difference between a bracing and a relaxing station is simply that of shelter from winds. The windier a resort the more bracing it will prove to be.

In recommending sea-side treatment for a child, the type should be carefully studied. The prevalent idea that all children do well at the sea-side is, as Sir Henry Gauvain pointed out, incorrect. For his experience shows that the delicate marasmic child of muddy complexion and of lethargic habits, who does not bronze readily on exposure to sunlight and who has little or no power to respond to natural stimuli, rarely does well. The stimulus of sun, open air, and sea breezes makes too great a call on his vitality. Dry sunny inland resorts are much more suitable for this type of child.

Children suffering from anaemia and weakness following operations, such as the removal of adenoids, or convalescing from measles or whooping cough, provided their reaction to cold is normal, can be sent to bracing sea-side resorts in summer and autumn. The Thanet coast has for many years enjoyed a well-earned reputation for the climatic treatment of tuberculous adenitis and osteitis.

In the selection of a sea-side resort in Great Britain it should be remembered that the east coast is much drier and more bracing than the west, since on east coasts every sea breeze is an east wind. Only very robust individuals can withstand the piercingly cold winds of the east coast in the winter months. The west coast is milder but very wet; it is on the whole better adapted to children whose reactive powers are subnormal.

*British
resorts*

Mediterranean

The south coast is much milder than either of the above, and delicate children thrive extremely well at most southern resorts. If, however, a still warmer climate is considered desirable, the Riviera resorts, or those on the south-west coast of France or in Algiers, or the frequented stations in the Mediterranean islands may be recommended.

Indications

Arteriosclerosis requires a warm equable climate such as obtains in England at Hastings, St. Leonards, Bexhill, Worthing, and Sidmouth, and elsewhere at Majorca, Gibraltar, Madeira, the Canary Islands, South African sea-side resorts, and the British West Indies.

*Arteriosclerosis**Chronic bronchitis*

Climatic conditions have a considerable effect on chronic bronchitis, which is the chief cause of winter cough in elderly people in whom there is failure in the power of adjustment to such external conditions as cold and damp weather—which normally stimulate the appetite and the desire for exercise. If the powers of adjustment are inadequate the usual result is an attack of bronchitis or an exacerbation of catarrhal symptoms. For this reason wintering in a 'protective' climate is required, namely, one that does not make an undue call on the adaptive powers of the patient.

The climate which exerts a beneficial influence on aged and delicate subjects promotes a feeling of lassitude and weakness in the more vigorous. Such a protective climate is not found in England. The Cornish resorts are the warmest in the British Isles but they are damp and their rainfall is heavy. They may suit patients suffering from the dry type of bronchitis with an irritating cough and scanty expectoration, but these cases are in a minority. If the circumstances of the patient permit, a selection may be made from Egypt, the Riviera (Mentone, San Remo), Algiers, the West Indies, Madeira, or the Canary Islands. For more robust persons for whom a 'protective' climate is not essential there are many suitable winter resorts in England. Penzance, Falmouth, Sidmouth, and Torquay may be recommended for the dry bronchitis, and Hastings or Ventnor for those whose condition is characterized by cough with abundant expectoration.

Pulmonary fibrosis

Pulmonary fibrosis is a very chronic disease. The only relief is residence in a 'protective' climate if circumstances permit. If this is not possible, a dry resort such as Hastings, St. Leonards, or Worthing may be suggested. Hilly resorts where the patient cannot take walks without developing dyspnoea are not suitable.

Rheumatic diseases

The question about residence at the sea-side for rheumatic subjects is often asked. It is difficult to lay down any hard and fast lines. Each case has to be decided on its merits. It is, however, well to keep in mind the fact that the sea does not as a general rule suit rheumatic people. They frequently declare that their pain is worse and their stiffness is more pronounced. It is a very common and often repeated observation that brachial neuritis, sciatica, and many forms of fibrositis are much worse near the sea.

(3)—Inland or Continental Climates

(a) High Altitudes

A station between 3,000 and 3,900 feet above sea level is classed as 'Alpine', anything between 3,900 and 6,000 feet as 'High Alpine'. During the winter months, cold air in contact with mountain slopes descends, by reason of its increased density, to the valleys or lowlands and is replaced by warm air from above. In this manner an inversion of temperature is caused, in that in winter the mountains are warmer than the lowlands. Diurnal and annual variations of mean temperatures may approach those of marine stations.

Elevated enclosed valleys exposed to the sun's rays for the greater part of the day may have wide variations in daily temperatures. There may be as much as 70° F. difference between temperatures in the shade and in the sun. So long as there is no wind the dryness and stillness of the mountain air allow patients to sit or lie for hours in an exposed situation in perfect comfort.

There is usually more cloudiness on mountains in summer but the reverse is the rule with regard to the lowlands. The small amount of cloud adds greatly to the therapeutic value of the higher Alpine valleys during the winter. Fogs are rarely experienced over 1,000 feet above sea level.

Low wind-velocity and intensity of insolation are other important factors. The greatest wind-velocity in a mountainous region is usually at night, whereas in lowland districts it is usually during the day.

It will be remembered that at 5,000 metres elevation the pressure of the air is reduced to a little over half an atmosphere. At sea level with 100 per cent atmospheric pressure the barometer stands at 760 mm. Hg, while at 7,000 metres above this there is only 42 per cent of an atmosphere with the barometer showing 320 mm. Hg.

This diminished density of the air necessitates increased respiratory movements to ensure an adequate supply of oxygen to the organism. The increase thus brought about favours the development of the muscles of respiration and ultimately promotes the expansion of the chest and lungs. A definite increase in thoracic measurement of from one to three inches has been observed among those who indulge in winter sports at high altitudes. Deeper breathing opens up a good many air vesicles which in ordinary circumstances are more or less collapsed or partly filled with mucus.

The increase in the size and capacity of the lung results in a state known as 'hypertrophy' and differs from true emphysema by the absence of the signs and symptoms usually associated with that condition (see EMPHYSEMA).

Early pulmonary tuberculosis and its treatment at high altitudes are dealt with under the title SANATORIUM TREATMENT. Mountain air, by reason of its dryness and comparatively low temperature, has a stimu-

lating effect and is only suited to those capable of a certain amount of muscular activity.

Convalescence

Cases of retarded convalescence in otherwise strong and fairly robust individuals usually do very well; but if there is great muscular debility with severe exhaustion the highly stimulating air may serve only to increase the weakness.

Mental exhaustion

High-altitude treatment is also recommended in cases of mental debility caused by constant strain and anxiety. The cold and dry atmosphere exerts a bracing effect on the body generally and promotes a desire for exercise and an increased output of physical energy; and in addition, the quiet and stillness of the mountain regions have a soothing effect on the troubled mind.

Sensitivity to cold

Many persons with an undue sensitivity to cold are greatly benefited by a sojourn among the mountains. The dry and bracing air seems to have a powerful effect on the functional activity of their skin.

Circulatory disorders

High altitudes are definitely contra-indicated in circulatory disorders; the rarefied air has a bad effect on the cardiac muscle which is already insufficiently supplied with oxygen and any additional strain placed upon it may have serious consequences.

Naso-pharyngeal disorders

Some cases of chronic nasopharyngeal catarrh in young subjects derive great benefit from a stay of several months in a high-altitude resort.

Asthma

As in asthma the problem of treatment is purely individual, the impossibility of laying down any hard and fast rules is obvious. Many sufferers say they get relief from an annual or biannual visit to Mont Dore in the Auvergne district with an altitude of 3,400 feet, where climatic and spa treatment are combined. The outstanding feature of Mont Dore is the 'salle d'aspiration', a large hall filled with a warm fog obtained by passing steam through the mineral water and then atomizing more of it and adding it to the vapour in the room. The patients spend an hour or more in the room, during which time they are inhaling the medicinal elements contained in the 'pulverized' water. A similar treatment combined with an 'air cure' is carried out at La Bourboule.

(b) *Moderate Altitudes*

Resorts at altitudes between 1,500 and 3,500 feet above sea level are classed as 'moderate'. They may be just as bracing, and a great deal depends on whether the surroundings are much higher than the locality itself. It is quite possible to find stations in Great Britain at elevations considerably under 1,000 feet which are far more invigorating than places three or four times the height in southern Europe.

These places being warmer, on account of their lower altitude, the dampness of the air is increased and mists are much more common. Insolation is less intense and the snow does not remain on the ground so long.

Indications

As these climates are, on the whole, less bracing than those of a higher altitude, they are better suited for patients who have a tendency

to myocardial insufficiency or who have degenerative changes in their blood-vessels, as well as cases of pulmonary emphysema. Patients of irritable nervous disposition find these lower altitudes much more suitable as they are able to sleep better and their appetites do not tend to diminish. Keeping in mind what has been said about the selection of cases of psychasthenia for climatic treatment, if it is thought desirable to include some spa treatment a choice may be made of the following: Buxton, Bad Weiler, Bagnères de Bigorre, Bex, Badgastein, Rotorua (N.Z.), Caledon (S.A.).

(c) *Low Altitudes*

Inland climates of plains, more particularly in the temperate zones, are much drier and less equable than those under the influence of the sea or ocean. The winters are colder and the summers hotter. Places in the interior of the continent of Europe may have a difference of 50° F. between their mean January and July temperatures, whilst stations in Great Britain at about the same latitude will only show a difference of 20° F. in their mean temperature for those two months.

The inland climate of localities situated on the shores of, or on islands in, the great inland lakes may be greatly modified by the presence of so much water. Owing to the large evaporating surface the air is much moister, the daily range of temperature less, and the winters milder.

Purity of air must obviously form the chief climatic feature of a resort situated at a low altitude.

At some resorts in Europe (Reichenall, for example) the compression chamber is employed for the treatment of cases of emphysema and bronchitis. An extra pressure of half an atmosphere is produced and the patient remains therein for one and three-quarter hours. After a series of these treatments many patients say that their breathing becomes much easier and that they are capable of taking more exercise with less dyspnoea.

Indications

*Emphysema
and
bronchitis*

Rheumatic diseases are usually benefited by a sojourn in a dry warm climate of no great elevation. Most sufferers from chronic rheumatism are what the French describe as *barométrique*, in that they are able to predict changes in the weather by the exacerbations of pain which they experience at such times. Some forms of chronic rheumatism (rheumatoid arthritis and fibrositis of the muscles and nerves) appear to have a greater incidence in cold damp climates. There is every reason to assume that there is much less articular and non-articular rheumatism in warm equable climates such as Egypt, South Africa, and Florida, and great benefit can be gained by residence in such favoured surroundings.

*Rheumatic
diseases*

Myocardial disease is usually well treated at resorts of low altitude. A combination of baths and waters is generally available.

(4)—*Desert Climates*

The atmosphere over large areas of dry ground must of necessity be itself dry. The greater transparency of the air prevents the formation

of fogs, and clouds are less frequent. During the night, the sky being cloudless and the air dry, heat is very rapidly radiated and in consequence the difference between the day and night temperature is very marked. Owing to the abundance of light, the dryness of the air, and the absence of population, the atmosphere is free from organic impurities. This does not of course apply to the dust storms which in some parts of America and Africa are very frequent at certain times of the year.

Indications

Parenchymatous and chronic interstitial nephritis in their earliest stages do very well provided every care is taken to avoid chills after sundown. If the Egyptian desert is chosen, Assouan is the best station. The climate of South Africa is also suitable for renal affections of various kinds.

Catarrhal conditions affecting the bronchi, larynx, and pharynx, more particularly the moist variety, all gain considerable relief. Patients with dry catarrh should not be sent as the dust is apt to prove most irritating. Rheumatic conditions of all kinds are usually greatly helped by a few months in the desert. The dryness has a very favourable influence on these cases.

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CLIMATIC BUBO

See LYMPHOGRANULOMA INGUINALE

CLITORIS

See VULVA DISEASES

CLONORCHIASIS

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Reference may also be made to the following title:

LIVER DISEASES

1.-DEFINITION

(*Synonym.*—Clonorchiosis)

245.] Clonorchiasis is an infection of the biliary system with the trematode, *Clonorchis sinensis*, with the production of a chronic form of cirrhosis of the liver, often terminating fatally, with symptoms of diarrhoea, jaundice, and ascites.

2.-AETIOLOGY

*Geographical
distribution*

C. sinensis is found in China (principally in the south), in Japan, Korea, Formosa, and French Indo-China. Cases have been reported from many parts of the world, but always in Chinese or Japanese who have brought the infection from endemic centres in their native lands. Recently four cases have been reported in Hawaii in native lepers who have never been out of the islands, but even here the

indigenous nature of the infection is doubtful, as for many years past a great deal of frozen and pickled fish has been imported into Hawaii from China.

In all countries where this infection occurs the distribution is very patchy and in China, where the epidemiology has been exhaustively studied by Faust, differences in infection-rates in different parts of the country, both in human beings and reservoir animal hosts, can be explained either by the presence or absence of the intermediate hosts or by the opportunities for obtaining infected fish. An instructive example is given by Oldt who found that in Canton the better-class business men were more heavily infected than either their wives or the poorer classes of either sex. The reason for this is that fish is eaten mainly in restaurants to which the women do not go; and, as fish is expensive, the poorer people cannot afford it and therefore escape infection. Moreover, dogs and cats are only rarely infected in Canton because fish, being expensive, is reserved almost exclusively for human consumption.

Incidence

3.—PARASITOLOGY

The parasite is *Clonorchis sinensis* (Cobbold, 1875; Looss, 1907). Like most parasitic worms that have been extensively studied, this fluke has been given many names by different workers, but the only synonyms of importance are *Distomum hepatis endemicum* (sive *perniciosum*) Baelz, 1883, and *D. hepatis innocuum* Baelz, 1883, because he considered that there were two species, one harmful and the other harmless. The former was changed by Looss to *Clonorchis endemicus* Looss, 1907, who agreed with Baelz that there were two species. This view is now entirely discounted by modern parasitologists and only one species is recognized.

Synonyms

The adult worms measure from 10 to 25 mm. in length and from 3 to 5 mm. in breadth (see Fig. 25). They are pinkish or brownish, semi-transparent and leaf-shaped, slightly broader and rounded posteriorly, and tapering towards the anterior extremity. In young worms there are spines on the cuticle but these are soon lost. The anterior sucker is situated at the anterior extremity and looks directly forwards; the slightly smaller ventral sucker or acetabulum lies at about the junction of the anterior and second fourths of the body, and the genital pore opens immediately in front of it. The muscular pharynx arises close behind the anterior sucker and leads into the short oesophagus, which divides into two caeca which extend posteriorly lying roughly parallel to the margins of the worm, and end a short distance from the posterior extremity. The branched testes, which extend beyond the caeca on each side, are placed directly one behind the other in the posterior third of the worm, and the two vasa efferentia, passing forwards, unite in front of the ovary to form the vas deferens. This tube dilates into the vesicula seminalis which enters the genital atrium

*Description
of adult worm*

situated in front of the ventral sucker; this worm has no cirrus or cirrus-pouch. The ovary, shell gland, and a relatively large receptaculum seminis lie immediately in front of the anterior testis; the uterus, composed of closely-set transverse coils, occupies practically

the whole space between the ventral sucker and the female genitalia, in the area bounded laterally by the intestinal caeca; the vitelline glands occupy the lateral fields external to the caeca and they extend from the level of the ventral sucker to the ovary. The excretory bladder begins at the level of the ovary and pursues a somewhat sinuous course posteriorly to open in the centre of the posterior border.

The eggs are oval and have a slightly flask-shaped outline as there is a distinct shoulder on which the operculum rests; at the opposite pole a small hook- or knob-like prominence is seen if the egg is suitably orientated (see Fig. 26). They measure 27 to 35 μ by 11.5 to 19.5 μ .

The eggs of *C. sinensis* do not hatch until they have been ingested by a suitable snail. *Parafoassalurus striatulus*, *P. striatulus* var. *iaponica*, *Bithynia fuchsiana* and *B. longicornis* have been proved to be favourable hosts, and it is considered that certain species of *Melania* may, on certain occasions, possibly act as transmitting agents. The eggs hatch in the oesophagus of the snail and the miracidia immediately escape through the wall into the peri-oesophageal lymph space

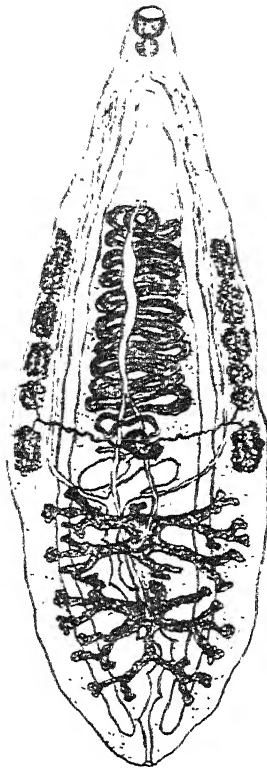


FIG. 25.—*Clonorchis sinensis* (ventral view) $\times 6$

where they develop into sporocysts; the sporocysts migrate through the tissues of the snail to the intra-hepatic lymph sinuses and here produce a crop of rediae; lophocercous cercariae develop within the rediae. The cercariae burst the walls of the rediae and so come to lie in the lymph spaces within the snail; finally the cercariae rupture the outer wall of the mollusc and escape into the water.

When the cercariae come into the proximity of certain fish they discard their tails, burrow beneath the scales, and so gain entrance to the muscles of the fish, where they encyst. It is probable that almost any fresh-water fish in a suitable climate can act as an intermediate host, for Kobayashi has recently listed 40 species from the families Cyprinidae (37), Gobiidae (2), and Anabantidae (1), which have been proved to be carriers in various areas where clonorchiasis is endemic.



FIG. 26.—Eggs of *C. sinensis* $\times 300$. (After Looss)

Eggs

Life history

Stage in the snail

Stage in fish

When such an infected fish is eaten either raw, or preserved in such a way that the encysted cercariae are not killed, these small parasites are able to escape into the duodenum after the cysts have been weakened by the process of digestion. The larvae immediately make their way up the common bile-duct into the liver; they then proceed to the smaller distal bile-ducts, where they grow to maturity and pass their adult existence, which may last as long as twenty-five years. The numerous eggs produced by these parasites pass down the bile-ducts to the duodenum where they mingle with the intestinal contents and so reach the outer world in the faeces and commence the cycle once more.

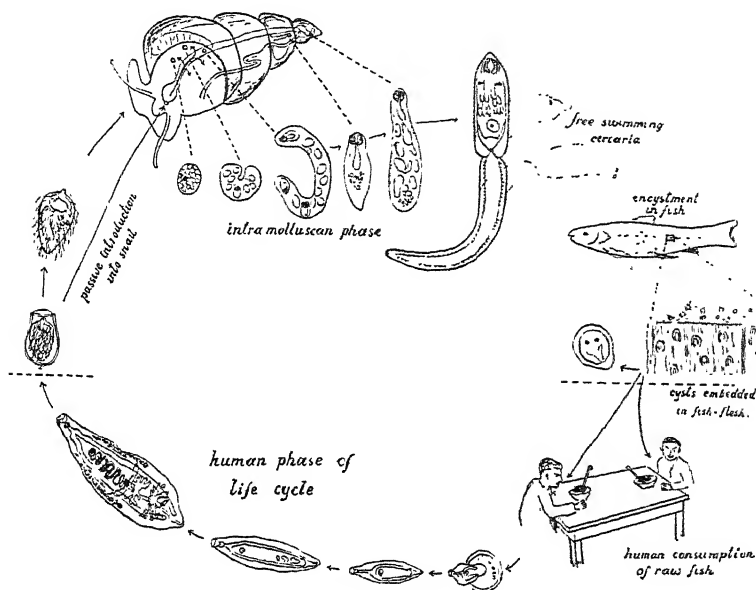


FIG. 27.—Schematic representation of life history of *C. sinensis*
(From *Human Helminthology*, by E. C. Faust)

Man, cats, and dogs have been found naturally infected in all the countries in which *C. sinensis* has been recorded. In addition, in China, the marten, wild cat, badger, and guinea-pig are natural hosts; in Japan weasels, and in Korea the Siberian mink have been found infected; finally cats, dogs, rabbits, and guinea-pigs are readily infected experimentally.

This parasite was first discovered in 1874 by McConnell in the bile-ducts of a Chinaman who died in the Medical College Hospital, Calcutta. It was found in Japan in 1875, but was first properly described in 1883, by Baelz. Although it was recorded in Chinese in various parts of the world on many occasions in the ensuing years, it was not until 1908 that any record of its presence in China was published. The life-cycle was elucidated by the Japanese parasitologists, especially Kobayashi and Moto; in 1927 an exhaustive monograph on the parasite—its

distribution, epidemiology, and life history—was published by Faust and Khaw, since when not much of note has appeared.

4.—MORBID ANATOMY

With the exception of the pancreas, which, especially in heavy infections, occasionally contains parasites, the true effects of clonorchiasis



FIG. 28.—*Clonorchis sinensis* in bile-duct; wall of duct thickened and showing numerous glandular structures. $\times 24$. (*Chinese Medical Journal*, 1933)

are confined to the liver, the other morbid conditions described in this disease being really secondary to the hepatic damage.

*Cirrhosis
of liver*

The infection produces a cirrhosis of the liver; the larger bile-ducts are dilated and their walls thickened by fibrosis, which also extends throughout the portal interlobular system beyond the immediate sphere of the affected ducts. In some instances there is intra- as well as interlobular fibrosis with attendant fatty and hyaline degeneration in the liver cells. Eosinophil cells may or may not be a prominent feature throughout the fibrous tissue. The epithelial lining of the bile-ducts hypertrophies and gives rise to definite adenomatous proliferation, and new bile-ducts appear. This activity of the bile-ducts is considered by many authorities to be a precursor of primary carcinoma of the liver.

Hoeppli studied in detail the livers of 66 Chinese who died from various causes, many of them accidents, in whom *Clonorchis* infection was unsuspected but found at necropsy. The summary of his work is that considerable liver damage occurs before clinical symptoms appear;

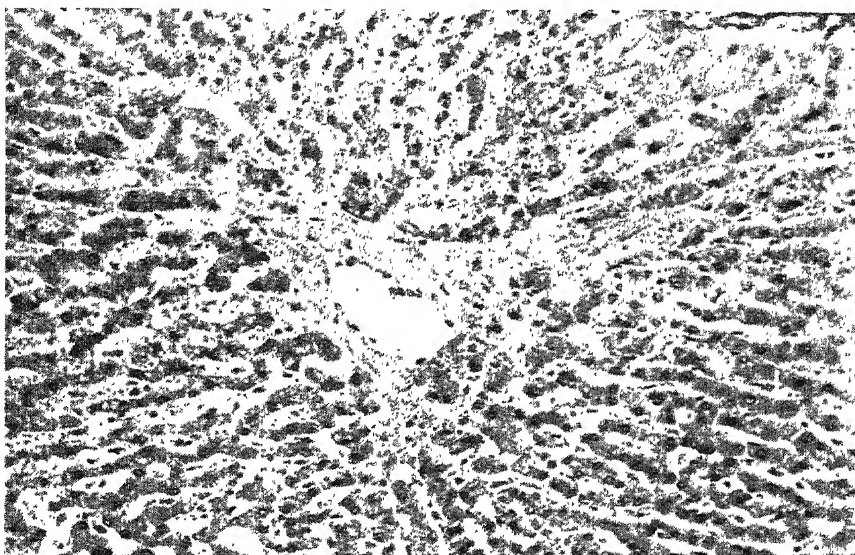


FIG. 29.—Fibrous thickening around central lobular vein extending between liver cells. $\times 155$. (*Chinese Medical Journal*, 1933)

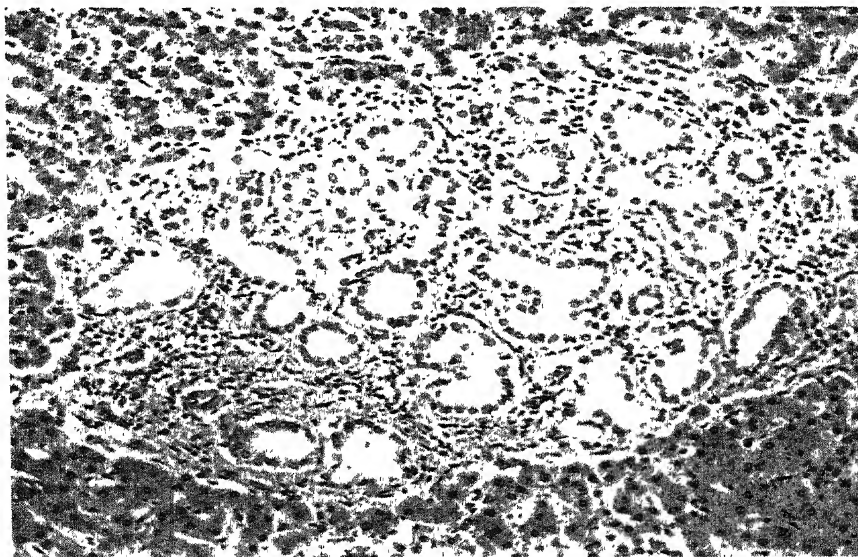


FIG. 30.—Dilatation of numerous newly-formed bile-ducts. $\times 155$. (After Hoepli)
(*Chinese Medical Journal*, 1933)

cirrhosis is apparently a late result of the infection as he found only two cases with this condition fully developed; he recorded, however, inter- and intra-lobular fibrosis with fatty change in the liver-cells in a large proportion; in five there was increased fibrous tissue round the central vein of the lobule, and in several others increased thickness of the intima of small arteries (see Fig. 29).

*Other
morbid
changes*

The spleen is frequently enlarged, probably as a sequel to the hepatic cirrhosis; other sequelae of cirrhosis may be present, namely, congestion and catarrh of the gastro-intestinal mucosa, ascites, and oedema.

5.—CLINICAL PICTURE

A considerable amount of damage may be present in the liver without symptoms, and even when the disease has advanced sufficiently to cause clinical manifestations these are not specially characteristic of clonorchiasis as opposed to other forms of hepatic cirrhosis.

The symptoms may be summarized as follows:

*Gastro-
intestinal
symptoms*

The appetite becomes abnormal and is generally increased, and often remains so until a late stage in the disease. Diarrhoea is common and at first is irregular, but the intervals between attacks become shorter and shorter as the disease advances, and by the time cirrhosis and portal obstruction are well established there is often blood in the stools. There may be a sense of fullness in the hepatic region; the liver is enlarged and tender, sometimes reaching the umbilicus, and as the left lobe is frequently more heavily infected than the right, it is often relatively much more enlarged.

*Nervous
symptoms*

Nervous symptoms sometimes occur and increased reflexes have been described; paralysis has been recorded, but possibly beri-beri, though unrecognized, was also present in those cases. Night blindness is fairly common.

*General
symptoms*

As the cirrhosis progresses ascites, jaundice, and anasarca appear; the patient sinks lower and lower as the result of haemorrhage into the bowel, diarrhoea, and malnutrition, until he finally dies of exhaustion.

The blood

The blood-picture does not show any characteristic change, but there may be slight eosinophilia and polymorphonuclear leucocytosis.

6.—PROGNOSIS

The infection, if not cured completely, may be so much reduced in intensity by suitable treatment that further advance of the disease will not occur. It is also probable that persons will unconsciously carry light or moderate infections for years and will eventually die of some totally different disease. If the diagnosis is made after the liver cirrhosis is fully established, the prognosis is no more favourable than it is in any other form of hepatic cirrhosis.

7.—DIAGNOSIS

Any of the above symptoms in persons coming from an endemic area of clonorchiasis should arouse suspicion. The diagnosis can be definitely established by finding the characteristic eggs in the stools: they are indistinguishable from those of *Opisthorchis felinus* and *Heterophyes heterophyes*, and it should be remembered that they must be looked for in a direct smear as they are not demonstrated by any of the gravity flotation techniques employed for concentrating nematode eggs in the stools.

8.—TREATMENT

Prophylaxis may be effected in several ways which are indicated below, *Prophylaxis* but space does not permit of their being given in detail, and the reader is referred to books on sanitation—especially those devoted to tropical sanitation—in which the methods of dealing with invertebrate hosts of parasitic diseases are specially described.

(1) Stools in which eggs are present may be disinfected. (2) Stools should not come into contact with water in which the snail hosts are present. (3) The snails may be destroyed. (4) Persons should be prevented from eating infected fish in the raw state. (5) Access of cats and dogs to the flesh of infected fish should be prevented, and infected animals should be destroyed.

All the common anthelmintics for the treatment of intestinal helminths have been tried and, although some of them were originally considered of value, subsequent work has shown that not one of them is reliable. *Drugs*

Tartar emetic, on account of its lethal action on schistosomes, has been much used, and although it has apparently cured a good many cases it often fails completely. *Tartar emetic*

Fouadin (sodium antimony pyrocatechin-disulphonate), one of the newer antimonials, has been very efficacious in treating cats and deserves a trial in human infections; but, as it is said to cause hepatitis, it must be used with caution in a disease in which the liver is already considerably damaged. *Fouadin*

Probably the best drug is gentian violet, the action of which has been exhaustively studied by Faust. It may be given either by the mouth or intravenously. If given by the mouth it can be given in glutoid capsules or keratin-coated pills each containing 30 mgm. and administered every second day; to avoid danger of toxicity the total amount given should not exceed 300 mgm. Intravenously it is given at the same time-intervals in doses of 40 c.c. of a 0.5 or 1 per cent solution, and the total dose must not exceed 6 grams. *Gentian violet*

Injections of gold preparations, e.g. solganol B (aurothioglucose) or auroprotasin, have been used with apparent success by Otto and *Gold*

Tschan Tsching, but in view of the early favourable reports with other drugs, notably oil of chenopodium and tartar emetic, which have later proved of uncertain value or quite useless, the value of these gold preparations requires confirmation.

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CLUBBED HAND

See HAND, DISEASES AND DEFORMITIES

CLUB FOOT

See TALIPES

COAL GAS POISONING

See POISONING, HOMICIDAL AND SUICIDAL

COAL-MINERS' LUNG

See ANTHRACOSIS, Vol. I, p. 621

COCAINISM

See DRUG ADDICTION

COCCIDIOIDAL GRANULOMA

See BLASTOMYCOSIS, Vol. II, p. 405

COCCYX DISEASES

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Reference may also be made to the following title:

CHORDOMA

246.] The coccyx is not commonly the seat of pathological processes. By virtue of its mobility and the protection afforded by surrounding structures it is rarely fractured; inflammatory changes are uncommon and primary tumours of the bone are almost unknown.

1.-FRACTURE, DISLOCATION, AND BRUISING

Fracture

—

Fracture of the coccyx occasionally results from direct violence applied to the bone, for example, heavy falls on the buttocks, kicks, blows, and sometimes during parturition. The patient complains of localized pain accentuated by movement of the coccyx caused by sitting, walking, or defaecation. In addition to possible signs of external trauma, examination shows tenderness of the coccyx on pressure; excessive mobility of the bone may be elicited by the examining finger in the rectum, and typical crepitus may be felt. Since external fixation is obviously impossible, treatment is directed towards keeping the patient at rest in bed for about four weeks, after which time the fracture will usually be united.

Occasionally a similar injury causes dislocation at the sacro-coccygeal

joint, or at one of the joints between the components of the coccyx. (The four coccygeal vertebrae usually become ankylosed during early adult life, the union taking place from below upwards between the eighteenth and the thirtieth years.) In these cases the symptoms are not so severe as in fracture of the bone. The condition is diagnosed on palpating the movable bone per rectum. Crepitus is absent. Radiological examination may differentiate the condition from fracture.

Perhaps more common than either fracture or dislocation is bruising of the coccyx and its ligaments, resulting from external trauma. The symptoms date from the causative violence, and, in the absence of adequate rest in the early stages, are apt to become chronic and resistant to treatment. *Bruising*

2.—COCCYDYNIA

(*Synonym.*—Coccygodynia)

Coccydynia is the term applied to a clinical condition in which pain is felt in, or referred to, the coccyx. The pain may be constant and subject to exacerbations, or it may occur only when the subject adopts a posture causing movement of the bone, e.g. sitting or defaecating. It is often extremely severe and out of all proportion to the signs found on clinical examination. In some cases the over-reaction of the patient to painful stimuli is evidence of an unstable mentality and indicates the appropriate line of treatment. *Definition*

The pathogenesis is varied. Some cases are undoubtedly associated with malunited or ununited fractures of the coccyx, resulting from absence of treatment, or even following adequate treatment; others are probably due to fibrosis following haematoma in the neighbourhood of the coccygeal ligaments, involving sometimes the muscular origins of the pelvic floor, and sometimes the sacro-coccygeal nerves; other cases, seen almost exclusively in young females following slight trauma or parturition, appear to be devoid of any organic basis, and may be the physical expression of an anxiety neurosis. *Pathogenesis*

Beyond revealing a localized tenderness confined to the region of the coccyx, physical examination is usually negative. In some cases, however, the coccyx is deformed or fixed, or surrounded by palpable thickening of its ligaments. Radiological examination confirms the clinical findings and may reveal an unexpected bony lesion. *Clinical picture*

Treatment depends upon the cause. Some cases are benefited by sedatives or by local medical diathermy; those associated with mental symptoms should receive the appropriate psycho-therapeutic investigation and treatment; cases in which local tenderness is associated with demonstrable abnormality in the coccyx are usually unrelieved by medical measures and are best treated by excision of the bone. *Treatment*

3.—ANKYLOSIS

Bony union between the last piece of the sacrum and the coccyx may occur in advanced age. In the majority of cases there are no symptoms.

4.—TUMOURS

In 1847, Anderson reported a case of 'a hair extracted from an ulcer of the coccyx', and since then tumours in this region have been regularly reported. Their pathology, however, is not well understood and the nomenclature is very variable. The tumours have been called dermoids, pilonidal cysts or sinuses, teratomas, foveola coccygea, and medullary defects of the sacro-coccygeal region. Aetiologically they have been termed 'a monstrosity by inclusion', 'a cicatrix of the spine where the tail has been lost', 'due to the pull of the filum terminale', and so forth.

The primitive structures in this region from which tumours can develop are: (1) the coccygeal pit and coccygeal vestiges of the neural canal; (2) the neurenteric canal; (3) the post-anal gut; (4) the procto-deal membrane; and (5) the skin epithelium of the coccygeal region.

The tumours may be variously grouped as: (1) anterior or posterior meningoceles; (2) teratomas; (3) dermoid cysts (*synonym* pilonidal cysts); (4) chordomas from notochordal remnants; and (5) tumours of normal structures, lipomas, lymphangiomas, chondromas, and sarcomas.

Sacro-coccygeal cyst

Of all these tumours the only one occurring with any degree of frequency is the sacro-coccygeal cyst or pilonidal cyst. This, when infected (as it usually becomes), breaks down and opens by numerous sinuses. The characteristic of the pilonidal sinus is the presence of hair without the existence of hair follicles. This cyst does not, like the true dermoid, contain sebaceous material. The frequency of these tumours is about 1 in 2,000. Males predominate, but a family history is most exceptional. Other congenital malformations are rare. About 90 per cent of cases are infected by the time the surgeon is called in.

Treatment

Free excision down to the ligaments over the sacrum and coccyx is the only satisfactory method of dealing with the tumour. Opinions differ, however, as to the correct subsequent procedure. Suture of the wound in the past always led to infection and multiple sinuses—a condition usually diagnosed as 'recurrence of the tumour'—but probably always the result of infection. Hence the treatment recommended was to pack the wound and to allow it to heal by granulation. This, however, is a most unhappy method, the patient being invalided for many weeks or months. Primary suture can be made effective if no catgut be used and mattress sutures are introduced to avoid leaving a dead space.

Primary tumours of the coccyx itself are so rare as to be pathological curiosities. The coccyx may, however, be involved by direct extension of malignant tumours arising in its vicinity, and may be eroded by the pressure of innocent tumours. Carcinoma of the ampulla of the rectum may in its late stages invade the coccyx; metastases from carcinoma of the prostate, osteoblastic or osteoclastic, occasionally involve the coccyx, but not nearly as frequently as the other pelvic bones. Sarcoma arising in the soft structures in the pelvis, and chondrosarcoma of the ilium and sacrum, have all been recorded as involving and destroying the coccyx in rare cases. In some cases of sacro-coccygeal chordoma the coccyx has been infiltrated by growth.

*Secondary
tumours in
coccyx*

5.—COCCYGEAL BODY

In front of and slightly below the tip of the coccyx, lies the small irregularly oval body known as the coccygeal body. There may be several smaller nodules near the main mass, which is about 2.5 mm. in diameter, and consists of irregularly placed masses of round or polyhedral cells. Each mass is grouped about a dilated blood capillary or sinusoid. Each cell contains a large, round or oval nucleus. The details of development of the coccygeal body are uncertain as it cannot be identified with accuracy before the fourth month. It is thought to arise from chromophil cells of the sympathetic system, but this is open to question. This gland has nothing to do with any tumour formation.

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COELIAC DISEASE

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Reference may also be made to the following titles:

MEGACOLON

SPRUE

1.—DEFINITION

(*Synonyms*.—Idiopathic steatorrhoea, Gee's disease)

247.] Coeliac disease is a digestive disorder arising in infants and young children without any signs of chronic intestinal or other organic disease; it is characterized by a persistent malabsorption of dietetic fat, causing large stools which contain an excess of split fat, with enlargement of the abdomen, lack of growth, and other symptoms.

Historical

Coeliac disease was first described by S. Gee in 1888 under the title of 'the coeliac affection', and since then cases have been described under various names: 'acholia' (W. B. Cheadle, 1903), 'pancreatic infantilism' (B. Bramwell, 1902-15), 'intestinal infantilism' (C. A. Herter, 1908), 'Verdauungsinsuffizienz' (O. Heubner, 1909), 'die Coeliakie' (H. Lehn-dorff and H. Mautner, 1927). In England it is sometimes referred to as 'Gee's disease', but more commonly under the title used at the head of this article; and although it would be preferable to substitute the word 'disorder' for 'disease' the term 'coeliac disease' has the advantage of not committing us to any particular hypothesis as to its cause. The terms 'idiopathic steatorrhoea' and 'non-tropical sprue' have lately

come into use, chiefly in connexion with cases seen in adult life, as described later (see p. 267).

2.—PATHOGENESIS AND AETIOLOGY

The essence of coeliac disease is the malabsorption of the fat in the food and the cause of this is not yet understood. It is not due to pancreatic insufficiency, since the faecal fat is always adequately split; nor is it due to chronic enteritis, since this is not persistently present; nor is it the same disease as sprue. Two hypotheses would explain coeliac disease but neither of them can be substantiated: (i) a failure of the bile-salts to do their part in assisting in fat-absorption; or (ii) some form of obstruction in the lacteal system hindering absorption of fat from the bowel. *Pathogenesis*

Autopsies, which are uncommon in coeliac disease, fail to provide any adequate explanation of this long-lasting disorder. Often the changes found are chiefly those secondary to emaciation, but sometimes there is oedematous swelling of the walls of the lower ileum with an unusual loading of the mesentery with fat.

With the essential cause of the disease still obscure other aetiological factors are of secondary interest. It is slightly more common in girls than in boys and occurs equally amongst the children of the rich and poor. The age incidence is of more importance. The disease usually starts between the ninth and twenty-fourth months of life, with a maximum incidence at the eighteenth month. There may be a previous history of feeding difficulties, but this is not invariable. Cases have been reported as starting as late as the fifth or seventh year and it has been claimed that the disorder may arise even in adult life, but when the disease starts insidiously it may be very difficult to date its onset. *Incidence*

3.—CLINICAL PICTURE

The onset of coeliac disease may be abrupt or gradual. The former is more common in such instances as arise towards the end of the first year of life than in the usual case arising at eighteen months. In this abrupt type the baby may suffer from vomiting with looseness of the bowels for two or three days, when suddenly the motions become quite white. After a few days splashes of green appear in them, and improvement occurs which may be mistaken for a true recovery; but in many such instances fat-absorption remains defective and the picture of coeliac disease gradually displays itself. Usually the onset of the disease is more insidious. The child begins to suffer from some obscure indigestion with vomiting and loose stools, and after a time the motions begin to lose their colour, grow bulky, and gradually become typical of coeliac disease. Vomiting is more conspicuous at the onset than later. *Onset*

Varieties

Cases of coeliac disease are not all equally severe. In the classical type as described by Gee the symptoms are at their worst and the stools are large, pale, unformed, and highly offensive. In the milder non-diarrhoeic type, the stools are more normal in appearance and the other symptoms are less pronounced.

Signs and symptoms

The cardinal features of the fully developed disease are excess of split fat in the stool, enlargement of the abdomen and wasting of the buttocks, anorexia, retardation of physical growth, nervous symptoms, and fever.

Stools

When a child passes an excess of fat by the bowel two features are invariably present: the motion is larger than normal for the amount of food taken, and constipation is unknown. Otherwise the appearance of the stool depends on the percentage of fat it contains and the form in which the fat is passed. Thus if the excess is unsplit or neutral fat, the stool is soft and oily, the 'butter-stool' of pancreatic insufficiency. In coeliac disease this is not seen, as the faecal fat is invariably well split. But the stool containing an excess of split fat will vary in appearance depending on whether the bulk of the fat is fatty acid or soap. If the amount of fat in the stool is very high (50 to 80 per cent of the dried faeces), intestinal hurry will probably be present and a large proportion of the faecal fat will be in the form of fatty acid; this is the typical pale porridge stool of coeliac disease. On the other hand, if the amount of fat in the stool is less excessive (30 to 50 per cent), there is less hurry and more time for saponification, and a large proportion of the faecal fat is in the form of soaps, and the stool, though more bulky and greasy than the normal stool, is formed, coloured, and not markedly offensive. Such stools are seen as the result of treatment or in the milder cases of coeliac disease, and are not easily recognized as being unduly fatty. Hence the importance of realizing that stools containing an excess of fat are always larger than normal.

Typically in coeliac disease there is diarrhoea without frequency of defaecation. The characteristic porridge stool is passed once or twice in the twenty-four hours, and usually the chief evacuation takes place about midnight or in the early morning hours. Such a stool may weigh up to 1½ pounds. From time to time, unless treatment is being properly carried out, there may arise periods of real diarrhoea with six or eight actions in the twenty-four hours. These appear to be due to an added enteritis and the motions become more watery and contain mucus and undigested food of all sorts. They may be gassy from impaired starch digestion. The soapy stool of the milder or improved case is usually passed once a day only, generally in the morning.

Pain is not a prominent feature, but it is common to hear of abdominal pain for a short while just before the bowels act. In the periods of enteritis colic is more frequent. Excess of flatus is the rule.

Under treatment the stools become much smaller and darker and less frequent. The development of constipation may be a welcome sign. With the strictest treatment it is rare to obtain a reduction of the proportion of fat in the stools below 15 per cent of the dried faeces, and this tends

to confirm the diagnosis of coeliac disease. A more common proportion attained by treatment is 20 to 25 per cent, but as a whole the patients do better with under rather than over 20 per cent of fat in the dried stool. As already suggested, the higher the proportion of the faecal fat that is in the form of soap, the better the case is progressing.

The abdomen is constantly distended in coeliac disease and is at its maximum in the evening before the bowels act. The distension is due to gas and faeces in the intestines and perhaps to overloading of the mesentery with fat. On palpation the abdomen is described as 'doughy', and

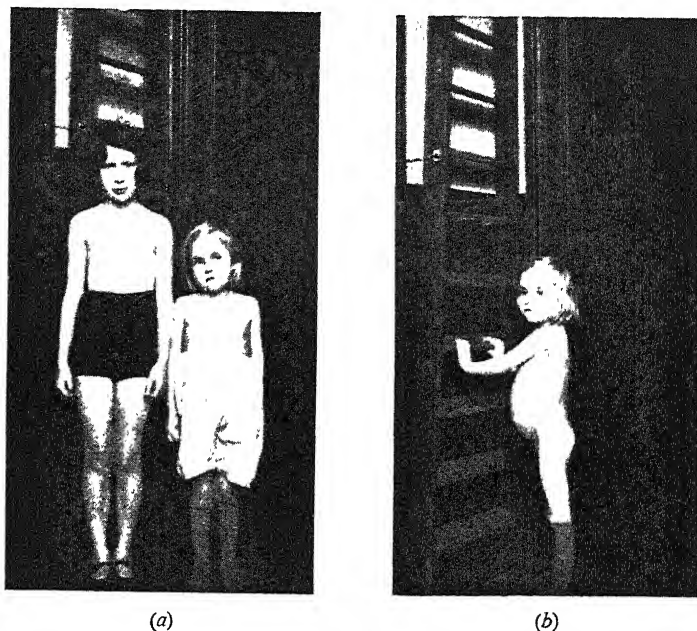


FIG. 31.—(a) Case of coeliac infantilism, aged 9 years, with normal child of same age: showing stunted growth. (b) Same case: showing abdominal enlargement and wasting of the buttocks and legs

it is characteristic that nothing abnormal can be felt within it. The spleen is never enlarged and the liver is seldom palpable. The abdominal wall tends to remain fatter than in abdominal tuberculosis. The buttocks are usually curiously small, more constantly than in other forms of digestive disorder in children, and the association of abdominal enlargement and gluteal atrophy is often striking.

Anorexia is constant and very severe, and there is hardly any subterfuge to which an untreated patient with coeliac disease will not resort in order to avoid taking food. It seems to amount to a real loathing of food, and if food is forced on the child it will promptly be sick. Such behaviour is apt to be regarded as hysterical, but with strict dieting the appetite in a few weeks shows considerable improvement.

Growth in height is constantly retarded and often temporarily arrested

and, unless treatment is early and strict, the development of puberty is likely to be delayed. Well-marked infantilism is not rare in untreated or imperfectly treated cases. Further stunting of the growth may occur from the development of bending of the bones due to late rickets. This, which does not occur in properly treated cases, may develop at about the age of seven years.

Nervous symptoms

The nervous symptoms in coeliac disease are constant and characteristic. They give rise to a picture of an hysterical and unpleasantly spoiled child, and are frequently so much to the fore that the underlying physical disease is overshadowed by them. Nevertheless these symptoms are part of the disease: they vary in severity according to the condition of intestinal digestion, and they slowly subside as the case is properly controlled by treatment. They are presumably the result of the prolonged intestinal toxæmia.

Temperature

A persistent rise of evening temperature is very common, and many of the milder cases are brought to the doctor for this reason. In times of upset the fever may be considerable for a few days.

The above are the most constant and characteristic signs and symptoms of coeliac disease and the clinical picture of the child affected is fairly characteristic. The patient is small and doll-like with a great loathing of food and a most difficult temper; its abdomen is much distended and its buttocks are flattened, and in spite of eating so little it passes at least one large motion each day, which from time to time tends to be pale and unformed.

Minor symptoms

There are, however, many less important symptoms. In the digestive system the tongue is usually coated, the breath offensive, and aphthous ulcers may occur on the tongue or gums. Hiccup is not uncommon. The heart is unaffected but the circulation is poor; the child feels the cold and may suffer from chilblains. The respiratory system does not show any peculiar changes. In an untreated case a secondary hypochromic anaemia is almost invariably present; but it is interesting to note that when symptoms have been present and uncorrected for many years, hyperchromic anaemia may develop as in sprue, though this is rare. There is commonly an excess of indican in the urine, but ketonuria is quite exceptional. Renal calculus is a rare complication. The bones are light, frail, and osteoporotic; the occasional occurrence of late rickets has already been mentioned. The nervous symptoms of rickets, particularly tetany, may occur. Pains in the legs on walking are often complained of and are probably due to the strain on the weak muscles. The knee-jerks are frequently absent, probably also because of the flaccidity of the muscles. Convulsions may occur and may follow within a few hours of a fatty meal.

Mental development

These children, especially when infantilism is well-marked, are often suspected of being mentally defective; but in spite of their distressing behaviour this is untrue. As they improve they show themselves quite up to the average in intelligence, and are often quite forward at the things which can be done by a semi-invalid, such as reading and paint-

ing. In their academic education they are, of course, apt to be behind-hand.

Certain comparatively rare cases of coeliac disease coming under observation in adult life have been described under the terms 'idiopathic steatorrhoea', 'Gee's disease', and 'non-tropical sprue'. To render such cases comparable with the coeliac disease of childhood it is necessary that the known causes of steatorrhoea in adults, such as pancreatic insufficiency, sprue, and abdominal tuberculosis, should be excluded: hence the use of the term 'idiopathic' steatorrhoea. Some authorities hold that coeliac disease, comparable to the disease of childhood, can develop *de novo* in adult life. This is a difficult question, and in practice such a possibility should not be too readily assumed. Certain it is that the vast majority of strictly 'idiopathic' cases of steatorrhoea in adults are merely coeliac children surviving to adult life with their disorder neither adequately treated nor spontaneously cured.

In this group of adult cases the steatorrhoea is associated with dwarfism, and as a result of the loss of calcium in the fatty stools there may be severe decalcification of the bones and such nervous disorders as tetany, laryngospasm, and facial irritability. Hyperchromic anaemia, comparable to that of sprue, is more common in the adult cases than in children. Enlargement of the colon may be of a degree sufficient to suggest a surviving but uncured example of Hirschsprung's disease.

4.—COURSE AND PROGNOSIS

Coeliac disease runs a prolonged course of years. It is incorrect to regard it as having phases of activity and quiescence; its ups and downs depend on details of treatment. When this is adequate, progress, although slow, should be smooth. With treatment an occasional case will clear up by the age of eight or ten years, but commonly even at fourteen these children will need such a modified diet as to make it difficult for them to go to public boarding-schools. By seventeen most are on ordinary diets, but for years later they will be upset by such food as Devonshire cream. Left untreated it is to be supposed that many recover spontaneously, but some remain severely dwarfed, and in rare instances in adult life develop bone changes, tetany, and hyperchromic anaemia (Bennett, Hunter, and Vaughan, 1932).

Chief anxiety concerns the growth in height; it is true that disastrous stunting may be permanent, but this is rare. Usually, by growth continuing later than the normal age, something approaching average height is attained. It is sometimes said that full stature is never attained, but this is untrue; the affected child may grow to be taller than either unaffected parent. Puberty is likely to be late ('coeliac infantilism').

Fatalities in coeliac disease are uncommon and almost entirely confined to children under the age of five years who are severely

emaciated before coming under treatment. The disease, even with its prolonged semi-invalidism, seems never to predispose towards tuberculosis.

5.—DIAGNOSIS

Examination of faeces

In its more severe forms coeliac disease is easily recognized: the stunted doll-like child, so large in front and flat behind, with anorexia and a temperament that makes it a misery to itself and everyone near, presents a characteristic picture. If the stools are persistently of the classical type, large, pale, and porridge-like, the diagnosis can hardly be in doubt. In milder cases greater difficulty arises. The clinical picture is on the same lines, but the abnormalities are less extreme. The suggestive features here are the size and regularity of the stool in spite of the sparse diet taken. Such a story should lead to a careful microscopical examination of the faeces for excess of fat (and possible lamblia infection), and if excess is present the percentage of fat in the dried stool should be determined by analysis. In addition to giving the total percentage of fat, the analysis should give the amounts of neutral fat, fatty acids, and soaps in percentages of the faecal fat. If more than 25 per cent of the faecal fat is in the form of neutral fat pancreatic insufficiency should be suspected.

Normal dried faeces may contain up to 25 per cent of fat. Between 25 and 35 per cent is abnormal unless it can be explained by an excess of fat in the food. Above these figures fat-absorption is definitely defective. In coeliac disease, even on a strict low-fat diet, the percentage of fat in the dried faeces rarely goes below 15 to 20 per cent; this is sometimes of confirmatory diagnostic value. It should be mentioned that it is often unwise to put a case of coeliac disease on a full fat diet for the purpose of reaching a diagnosis.

Differential diagnosis

An excess of split fat may be found in the stools in various conditions: overfeeding with fat, particularly in rickety infants; general impaired digestion of all food-stuffs; chronic enteritis, especially that due to tuberculosis or lamblia infection, or possibly to some chronic poison such as boric acid; obstructive jaundice; and lacteal obstruction, most commonly due to tuberculous mesenteric glands. Sprue, chronic dysentery, and chronic ulcerative colitis will be other possibilities, all very rare in childhood. In pancreatic steatorrhoea more than 25 per cent of the faecal fat should be in the form of neutral (unsplit) fat.

A transient occurrence of pale fatty stools (acholia) is not uncommon in connexion with vomiting, either of the so-called cyclical type or in association with chronic duodenal ileus.

6.—TREATMENT

Diet

In the early years of coeliac disease the fat in the diet must be kept strictly at a minimum. In severe cases in children under five years old,

when there is emaciation with a tendency to real diarrhoea with frothy stools, carbohydrates must also be restricted. In the later years more fat may gradually be introduced into the diet, but the commonest errors in treatment are either to fail to start strictly enough or to relax the diet restrictions too early.

The articles of a child's diet which are rich in fat are milk, gravy, meat-fat, butter, dripping, suet, yolk of egg, cream, sauces, chocolate, cocoa, nuts, and cod-liver oil. For milk, both for drinking and cooking, a desiccated separated milk, such as that sold by the vendors of Cow and Gate milk, should be used. It is practically fat-free and therefore for a strict diet is preferable to either machine- or hand-skimmed milk. For gravy, bovril or oxo should be used. Schweitzer's cocoatina is a low-fat cocoa. The rest of the foods given in the above list should be entirely omitted.

In the dangerous type of coeliac disease, i.e. in emaciated children under three or even five years of age, in which it is necessary to limit the carbohydrate intake as well as that of fat, it is best to start with the desiccated skimmed milk to which is added powdered sodium caseinate in the proportion of 20 grains to each ounce of reconstituted milk, the drink being sweetened with saccharin. With this may be given bovril or oxo, and pounded breast of chicken or rabbit. Carbohydrate, when introduced, may be given in the form of pulped ripe banana (which is fat-free), thin slices of bread or potato thoroughly toasted, and Benger's food. Later cornflour, arrowroot, and well-cooked rice may be given.

In older cases there is not the same anxiety and a palatable mixed diet may be chosen from the following:

Clear soup, bovril, oxo.

Meats: rabbit; breast of chicken; lean meat, minced; lean tongue.

Bovril for gravy.

Vegetables and fruits: all except nuts.

Puddings: jellies, sandwich and sponge-cake, meringue cases, boiled rice, milk puddings made with skimmed milk, stewed fruit.

Jams, treacle, honey.

Sandwiches: marmite, tomato, jam.

Relaxations of the diet should not be tried for a long time; they should then be permitted only occasionally and the result watched. An occasional egg or a small amount of lean ham may be given. As the child begins to tolerate more fat in the diet it is convenient to use less rigorously skimmed milk for cooking purposes.

The diet should supply full amounts of vitamins, which are easily given without introducing fat.

With correct dieting the necessity for medicines is small. Bile-salts ($\frac{1}{2}$ to 1 grain each of sodium glycocholate and taurocholate) may be given three times a day in a rhubarb and soda mixture. It is best to give them for alternate months and observe any improvement. The first course is usually the most efficacious. Dilute hydrochloric acid (20 minims) in a

Drugs

tumblerful of orangeade may be taken with meals. Anaemia should be treated with full doses of iron. The rare hyperchromic anaemia responds to liver therapy. Ultra-violet light is useful as a general tonic, and is necessary when rickets is threatening. Coeliac rickets responds to medical treatment, and operative measures are unnecessary.

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COLDS

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248.] The term 'common cold', though misleading in its connotation, *Definition* avoids the suggestion of a strictly localized process that is implicit in the terms 'acute rhinitis' and 'coryza'. It is defined as an acute catarrhal inflammation of the mucous membrane of the upper respiratory tract.

1.-AETIOLOGY

Of the various factors predisposing to the development of coryza, chilling *Cold and climate* of the body is the most popularly accepted although incapable of proof. Deliberate attempts to contract the condition by prolonged exposure to cold air or to sudden changes of temperature fail to achieve that aim. This age-old belief is probably based upon a misinterpretation of the significance of a sense of chilliness which may usher in a cold. It is a matter of common experience, however, that local chilling of the body, particularly of the feet, especially if associated with fatigue, is liable to be followed by coryza within twenty-four to forty-eight hours. Again epidemics of colds are most common when the humidity of the atmosphere is great and the temperature variable, but on the whole cool; when the weather is raw; or winds charged with cold rain blow, and the ground is wet and cold (Leonard Hill). Even these facts do not prove the direct influence of cold in the production of coryza. The result is probably indirect. Thus local chilling of the feet and ankles is usually associated with a warm and 'stuffy' atmosphere as in ill-ventilated

theatres. The climatic conditions mentioned above are just those which are liable to drive people into overheated and underventilated rooms. It is more important to consider the state of the nasal mucosa in these circumstances than the areas of the body which may be chilled. There can be no doubt that chilling of the whole body produces constriction of the superficial blood-vessels, including those in the nose. As we have seen, this state of affairs is not conducive to the development of coryza. On the other hand, when the head is in a warm stuffy atmosphere, whether the feet are cold or not, the mucous membrane of the nose and accessory sinuses becomes congested, boggy, and covered with a thick secretion. It is probable that it is this unhealthy condition which predisposes to coryza: in short, a cold may be induced by a warm, still atmosphere but not by cold.

It is in fact probable that the high incidence of coryza in the colder months of the year is attributable more to the measures taken to avoid the inclemency of the weather than to the actual atmospheric conditions: otherwise it is difficult to explain the remarkable freedom from colds enjoyed by troops, or by polar explorers, suffering the greatest hardships of exposure, and their tendency to relapse into this form of ill-health on returning to the comfort of civilian life.

Clothing

Over-clothing as a predisposing factor has not been sufficiently appreciated. The maintenance of good health depends closely on the functional integrity of the skin, and the popular fallacy that with the onset of autumn underclothing should be increased is no doubt in part responsible for the seasonal incidence of coryza. The heat regulation of the body is put to a hard task by such measures, which produce overheating during exercise and often irregular chilling by means of the sweat-laden coverings during rest.

*Smoking,
dust, and fog*

Tobacco smoking in excess, particularly indoors, appears to favour the development of coryza presumably by the pharyngeal irritation which it produces. The non-smoker may suffer in like manner from sitting in a smoke-laden atmosphere. An occupation in a dusty atmosphere exerts a similar influence. The great increase of colds in foggy weather is attributable to the injurious effect of the irritant atmosphere on the nasal mucosa.

*Individual
susceptibility*

Individual disposition to colds in the head is of some importance as an indirect cause of the disease. The unfortunate person who is highly susceptible will suffer from cold after cold on the slightest provocation. This tendency is influenced to some extent by age. In general it may be said that immunity to colds gradually increases after middle life.

Bacteriology

The various influences mentioned merely help to prepare the ground for the proximate cause of coryza, namely, infection. The nature of the responsible organism has not yet been determined, but there is much evidence in favour of its being a filter-passing virus. Experiments by Kruse and others conducted with a sterile filtrate from nasal discharges have done much to support this view. Thus 42 per cent of the volunteers

who were subjected to the intranasal instillation of such a filtrate developed typical coryza within two to three days. It is interesting to note that in the earlier stages of the disease the nasal discharge obtained from the upper reaches of the mucous membrane may be sterile. In every case of an uncomplicated cold the discharge is not rich in bacteria during the first twenty-four hours. Dochez, Shibley, and Mills successfully transmitted colds to apes and human volunteers in 44 per cent of instances by means of filtered nasal washings from cases of coryza. The general conclusion of the above workers is that a virus infection is the cause of the malady and that the presence of various common catarrhal organisms is a secondary feature responsible for the many complications which may from time to time arise. In the absence of any more obvious portal of entry of the virus, it may be assumed that the mucous membrane is unable to present an effective resistance as a filter. The infection is spread by those suffering from coryza and possibly also by carriers. Transmission is by droplets emitted during sneezing, coughing, and talking; also by the interchange of handkerchiefs, and kissing.

Streptococci, pneumococci, *Micrococcus catarrhalis*, *B. septus*, and *B. influenzae* are commonly found in the discharge and form a flora which is of some practical importance in relation to complications and their prevention. Secondary invaders

2.—CLINICAL PICTURE

Lassitude, chilliness, irritation or heaviness of the eyes, sneezing, and dryness of the throat are the common initial symptoms. The lassitude often amounts to true malaise and indicates invasion of the body often many hours before local signs of inflammation arise. Discomfort in the throat occurs early as the result of pharyngitis. Unless the attack is very mild, headache, loss of appetite, stuffiness in the nose, constipation and feverishness soon follow. The temperature may be raised, though seldom above 99.6° F. except in young children. The sense of smell is impaired or lost and a watery discharge from the nose is usually present within six hours of the onset. This may form a continuous drip and is then often associated with bilateral conjunctivitis. The eyes, however, are seldom affected to an equal extent, the more severely affected eye usually being on the same side as the obstructed nasal passage. The effect of any such abnormality becomes exaggerated by the turgidity of the mucous membrane induced by a cold in the head. Shooting pain above one eye or a throbbing pain on one side of the face may indicate extension of the disease to the frontal or maxillary sinuses. In a day or two the nasal discharge becomes more purulent, less copious, and more tenacious. There is a coincident diminution of malaise, and apart from the inconvenience of blocked nasal passages the patient may be free from symptoms in forty-eight hours. Symptoms
 In exceptional cases the return to normal is seldom effected in less than a week. In exceptional cases the return to normal is seldom effected in less than a week.
 open the door

to the almost constant development of an irritating unproductive cough indicating extension of the disease to the larynx and trachea.

A cold is fairly true to type for each individual. Thus one person will always become hoarse, another will suffer from conjunctivitis, and a third seldom escapes tracheo-bronchitis in any attack.

Immunity

A short period of immunity is conferred by an attack. In general it is uncommon for a second bout of coryza to occur in less than twelve weeks from the preceding attack, but to this there are many exceptions. It is noteworthy in this connexion that Dochez in his experimental transmission of colds to chimpanzees found that they developed regularly a three months' immunity.

3.—COMPLICATIONS

Tonsillitis

Tonsillitis may arise as a complication of coryza and then follows the onset of the disease in two or three days. This sequence is very constant for some patients, usually those whose tonsils are permanently unhealthy. Further complications, such as cervical adenitis or streptococcal fever, may arise therefrom. Neither of these is common, but in some cases, particularly in the presence of latent tuberculous adenitis, a severe cold is apt to lead to inflammation in the glands which may soon dominate the clinical picture.

Ear complications

Temporary deafness from Eustachian catarrh is common, and acute otitis media in children is usually preceded by the common cold.

Meningitis

The relation of meningitis to coryza is less clear, but both in the streptococcal and in the pneumococcal forms a history of a cold in the head occurring a few days before the meningitic symptoms is too common to be a coincidence. Here, as indeed in most of the complications, the developments are due to the secondary invaders of the respiratory tract rather than to the cold virus.

Conjunctivitis and sinusitis

Conjunctivitis and sinusitis have already been mentioned as occurring in mild form in many persons, but they seldom develop into severe purulent states of inflammation. Conversely, however, a chronic sinusitis undoubtedly renders the sufferers prone to repeated attacks of acute coryza. In this state, on account of the abundance of the discharge, they are highly infectious to others.

Laryngitis

Laryngitis is responsible for the hoarseness of the voice; and it is usual for the infection to spread to the trachea giving rise to an unproductive cough peculiarly persistent at night time. It follows that bronchitis must be anticipated, especially in the aged. In point of fact, some degree of involvement of the finer bronchi is of frequent occurrence in the course of a severe cold. Examination of the lungs at such a time seldom fails to reveal a few high-pitched rhonchi and possibly some scattered crepitations. The distribution of these signs is usually apical.

Bronchitis

~~lobular pneumonia~~ lobular pneumonia may appear as complications. The have done much thin four or five days of the initial coryza, whereas

broncho-pneumonia tends to occur later in the disease and is always preceded by an obvious downward extension of the oro-pharyngeal inflammation.

Oesophagitis is more frequent in women than in men and is characterized by pain and difficulty in swallowing, a sensation of a lump in the throat, usually at the level of the cricoid, and demonstrable redness and dryness of the oesophageal mucosa. In rare cases the process appears to spread to the stomach with the development of gastritis. Soreness in the epigastrium, sensation of fullness after food, nausea, loss of appetite, and outpouring of mucus in the gastric juice are of diagnostic significance.

The common cold may influence pre-existing diseases. Both asthma and diabetes mellitus are apt to be aggravated by the advent of coryza.

Of greater interest, however, is the relation of the common cold to pulmonary tuberculosis. The early history of the tuberculous usually includes a series of exhausting colds extending over many months before any sign suggesting pulmonary mischief is manifest. Does extreme liability to coryza connote exceptional susceptibility to tuberculous infection? Or does it merely indicate a state of lowered resistance which then attracts one or both maladies? Be that as it may, there can be no question but that an acute coryza may stir quiescent tuberculosis into an alarmingly active state.

Oesophagitis

Gastritis

Relation to pre-existing disease

Relation to tuberculosis

4.—PREVENTIVE MEASURES

In the absence of any specific prophylactic, prevention must depend upon avoidance of the various predisposing factors which have been described and upon efforts to raise the body's resistance to infection. Adequate house ventilation is of prime importance. Air movement is of great value and should be combined with warmth preferably from radiant heat directed towards the lower level of the room. In short, the aim is adequate ventilation, a warm floor and cooler upper air. Central heating and closed stoves are moderately satisfactory provided that the common mistake of closing all windows be avoided. The open grate has this in its favour that it creates a steady movement of air in the room and does not dry the atmosphere as does central heating. On the other hand, it rarely warms a large room efficiently, and thus local chilliness is often experienced. Gas heating is excellent in its distribution of warmth but should always be used in conjunction with a reservoir of water, the evaporation of which will counteract the excessive drying of the air otherwise induced. Electric heating, owing to the lack of air movement, produces lassitude; and if the windows are open, its power of raising the temperature is insufficient unless employed grossly uneconomically. Bedroom windows should always be wide open except in foggy weather. When the danger of fog is greater than that of stuffy rooms, some ventilation can be secured by leaving open the door.

Heating and ventilation of buildings

The habit of walking in the fresh air shortly before retiring has much to recommend it. The nasopharyngeal mucous membrane is thus revived from the effects of smoking and possibly whisky drinking in a warm room, and this simple measure will often appreciably diminish the number of colds each winter.

Clothing

The improvement in the last few years of the physique of women is an indication of the value of scanty attire. For the maintenance of health the skin must be stimulated by moving air of varying temperature—an end which is unattainable when the body is swathed in under-clothing. If the occupation entails immobility in cold air, the feet and legs should be warmly covered and an overcoat is desirable, but to have the body thickly wrapped in woollen garments throughout the day, without regard to variations in the atmospheric temperature, is illogical and harmful. Heavy bed-clothing should also be avoided, for it interferes with skin function and produces morning lassitude. If a hot bath is taken in the morning it should be followed by a cold douche. Ideally a cold bath should be taken on rising except by the weak and aged. It is a practice which may lead to complete freedom from colds.

Smoking

Those who suffer often from this malady should reduce materially their allowance of tobacco. Smoking should especially be avoided during the last hour of the waking day.

Pre-existing sinusitis

In patients in whom the above measures for the prevention of coryza appear ineffective, the possibility of chronic infection of the nasal sinuses must be considered and investigated. When operative interference is clearly indicated it should be carried out. In the majority of cases of chronic sinusitis there is no such clear indication, and some method of reducing infectivity may be employed. One of the best is the inhalation of vapour impregnated with menthol, which reduces the mucosal congestion, and with a volatile antiseptic. For instance:

Menthol	-	-	-	-	-	10 grains
Oil of eucalyptus	-	-	-	-	-	15 minims
Creosote	-	-	-	-	-	30 minims
Spirit of chloroform	-	-	-	-	-	25 minims
Alcohol, 70 per cent	-	-	-	-	-	to 2 fl. ounces

A teaspoonful should be stirred in half a pint of hot water, and the vapour inhaled through the nose for ten minutes on waking and at bedtime. The administration of oil of pine, camphor, or creosote as a fine nebula by means of the apneu inhaler is also of great value, though more expensive.

Vitamins

Experiments carried out by Hess and others on a large number of children showed that a liberal supply of vitamin A in the diet, and ultra-violet radiation, had not any effect in reducing the incidence of catarrhal infections; but opinions about their value are not as yet unanimous. To a good mixed diet such as may be obtained in most European countries it seems pointless to add concentrates of vitamins. ~~Vaccine~~ vaccine administration by injection, or by intranasal spray, is held

in high repute as a prophylactic. On the assumption that coryza is due to a virus it is difficult to countenance such a measure; but the evidence in its favour is considerable though not very convincing. For this two possible explanations present themselves. In the first place, if the common cold is due to infection by a virus it is certain that most if not all of the complications are due to the secondary invaders which have been enumerated. Vaccine administration may thus prevent the development of the more unpleasant symptoms with which coryza is usually associated. Secondly, it has yet to be proved that the common cold is a specific disease. It may be that in many instances the rhinitis, headache, and malaise can be produced by one or more of the organisms commonly found in the nasal discharge apart from any virus. If such is the case, then a mixed vaccine might be expected to bring great benefit to many persons. A point in favour of this hypothesis is that an overdose of mixed anti-catarrhal vaccine often initiates symptoms indistinguishable from those of the common cold.

It is doubtful if anything is to be gained by the use of an autogenous vaccine unless one organism predominates in all attacks. In most cases a stock mixed vaccine containing *Micrococcus catarrhalis*, streptococci, pneumococci, Friedländer's bacilli, Pfeiffer's bacilli, and staphylococci is suitable. The preparation should contain about 200 million of each organism to the cubic centimetre. The initial dose should not exceed 0.1 c.c. and injections should be repeated once in five days. The course may start in September and be continued throughout the winter. Each increment should be not more than 25 per cent of the preceding dose, and any sign of a reaction in the nature of malaise or coryza indicates an increase of interval and temporary reduction of dosage. When the quantity injected has reached 1 c.c. subsequent injections should be made once a fortnight in a slightly smaller dose than the maximum obtained. Certain patients are quite unable to tolerate so much as 1 c.c. without the development of coryza. In such cases a smaller maximum must be accepted as the optimum dose.

*Autogenous
vaccines*

The administration of vaccines by intranasal spraying is gaining in popularity. Twice daily at intervals of three days throughout the winter the patient sprays into the nose 0.25 c.c. of anti-catarrhal vaccine. The advantage of ease of application and reduction of cost is obvious, and it is claimed that the local resistance of the nasal mucosa is raised in addition to that of the body as a whole.

Of all forms of preventive measures clearly the most efficacious is the avoidance of persons obviously suffering from colds. Until, however, the public can be trained to consider the health of others this will remain a counsel of perfection which can but rarely be followed.

5.—TREATMENT

The general measures to be taken at the first signs must depend upon the age and physique of the

adult may rid himself of all symptoms by indulging in two hours of vigorous exercise such as football. Profuse sweating must be produced to secure this result. On the other hand, sweating by artificial means, e.g. Turkish baths, does not have this beneficial effect. A more striking method of curing a cold is to fly for at least half an hour at a height not less than 8,000 feet; on return to earth it is often found that a streaming cold has completely vanished. The mode of action of violent exercise, or of high altitudes, is not understood.

For the majority, however, treatment must be less dramatic. Immersion of the legs in a hot mustard bath rapidly eases the congestion of the nose and also helps to induce sleep. Hot whisky and water has the same effect by producing cutaneous vaso-dilatation, and relieving the initial sensation of chilliness. Thereafter 1 grain of calomel and 10 grains of Dover's powder should be given, and the patient should be induced if possible to stay in bed for at least twenty-four hours.

Diet

The diet in the feverish stage should consist of fruit juice, diluted milk, plenty of water, barley water or lemon squash, bread, butter, honey, and fish. In mild cases no special dietetic measures are indicated.

Drugs

Of drugs, none can claim to be specific. There is no justification for the use of quinine, which can only serve to depress leucocytic activity and never benefits a cold. Menthol and volatile oils as in the following:

Menthol	-	-	-	-	-	10 grains
Oil of eucalyptus	-	-	-	-	-	20 minims
Compound tincture of benzoin	-	-	-	-	-	60 minims
Alcohol, 70 per cent	-	-	-	-	-	to 1 fl. ounce

form a valuable inhalant. A teaspoonful of the mixture should be stirred into half a pint of water and the vapour may be inhaled frequently. This produces some degree of comfort in the early congested stage, and again later when the discharge is viscid. Alternatively compound benzoin spray B.P.C. can be used. The administration of belladonna is unjustifiable in theory because it dams up the nasal secretions. On the other hand, it proves in practice to be invaluable to those whose rhinorrhoea is excessive. Soreness of the nose, excoriation of the lip, and often conjunctivitis, can be prevented by the use of 10 minims of tincture of belladonna four-hourly. It is particularly useful for those who have to keep at work and furthermore it reduces their infectivity. The malaise is in no way benefited. Encouraging reports have been published on the use of benzedrine as an inhalant. Its effect is to reduce mucosal congestion and thus relieve headache and assist nasal breathing.

At the early stage when the nasal mucosa is dry and irritable, the application of Glegg's mixture may bring relief. It consists of soft white vasoline ad. part, and liquid paraffin, 4 parts: a teaspoonful of the mixture is put into each nostril whilst the patient lies on his back. This is to be repeated three times a day.

On headache and general discomfort may be

afforded by aspirin taken early in an attack. The sweating which it induces in some persons is clearly beneficial.

The tracheal cough which so often follows the rhinitis is best dealt with by Dover's powder in 10-grain doses at bedtime. The opium depresses the cough reflex, while the ipecacuanha, by virtue of its expectorant properties, causes an outflow of soothing mucus over the dry irritated mucous membrane. During the day syrup of codeine may be taken in doses of 2 fluid drachms every four hours.

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COLIC, BILIARY

See GALL-BLADDER AND BILE-DUCTS

COLIC, MUCOUS

See MUCOUS COLIC

COLIC, RENAL

See KIDNEY, SURGICAL DISEASES

COLIFORM BACILLUS INFECTIONS

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Reference may also be made to the following titles:

BLADDER DISEASES PREGNANCY PYELONEPHRITIS

1.—THE GENITO-URINARY TRACT

249.] The most common infection of the genito-urinary tract is caused by an organism indistinguishable both in appearance and behaviour from the bacillus found in the colon. It has been spoken of as the coliform bacillus because of the uncertainty whether it really is the *Bacillus coli* which has wandered from its natural habitat. If the species in the genito-urinary tract is the same as that in the bowel, some abnormal change must have taken place in the mucosa of the colon to permit its migration; but recognizable lesions of the bowel are rarely if ever associated with an attack of colon bacilluria. Possibly a morbid process is present but has escaped detection and becomes manifest clinically only by causing genito-urinary symptoms. Mottram showed that damage to the mucin-forming cells in the lower bowel of the rat allows the *Bacillus coli* to invade the deeper structures and enter the lymphatic stream. The mucin acts as a barrier to the migration of this organism through the mucous membrane. It is doubtful if the same

holds good in the human subject; for, were it so, every case of ulcerative colitis would be associated with colon bacilluria.

Origin of infection

There is some evidence that the organism responsible for the genito-urinary infection is introduced from without, and is therefore not the same as the one which has been present throughout adult life in the patient's colon. It is not uncommon for husband and wife to suffer from colon bacilluria within a short interval. From time to time epidemics occur in a household. The following instances may be cited. A man whose son and butler had previously had a *Bacillus coli* infection of the urinary tract developed a similar abscess of the testicle. Another example was that of a father and two sons, the former and one of the latter having orchitis, and the second son a prostatic abscess.

Preserved foods, milk, and water are by no means infrequent carriers of the *Bacillus coli*, and it is conceivable that in this manner the organism enters the body. The attack is so frequently ushered in by a rigor that there can be little doubt that in the majority of cases the genito-urinary tract is invaded via the blood-stream. In women, however, the close anatomical relationship between the cervix uteri and the base of the bladder lends itself to infection by way of the lymphatics; and Winsbury-White, by animal experiment, has shown such infection to take place.

Septicaemia

Colon bacilluria in the acute stage is a septicaemia in which there may be an entire absence of urinary symptoms. The kidney is an excretory organ and in the presence of a severe blood infection the offending organisms will be excreted by it in the urine. If the bacteria are not all expelled they become lodged in the renal cortex and chronic pyelonephritis results. Many cases of symptomless pyrexia mistakenly labelled with the diagnosis of influenza are due to the coliform bacillus.

Differential diagnosis

Persistence of colon bacilluria eventually leads, even in the acute stage, to inflammatory changes in the urinary tract manifested in various ways. The swelling of the mucous membrane of the right ureter is often responsible for the erroneous diagnosis of appendicitis. The appendix has been removed from an incredible number of patients with colon bacilluria. Further, the quadratus lumborum muscle is often erroneously held responsible for pain really produced by an acutely inflamed kidney but regarded as lumbago. Abdominal distension with flatulence and hiccup may also occur and temporarily lead to a wrong diagnosis.

Diagnosis

The correct diagnosis, however, is really simple if in all cases of pyrexia the urine is bacteriologically examined. The bladder may become involved at any stage of the disease, and it is by no means rare for an acute attack to be ushered in by a sudden escape of blood from the urethra at the end of micturition. This is followed by bladder strangury, frequency, and smarting pain on micturition. The male sex organs are just as likely to be involved in this type of infection as in any other from the upper urinary passages, and therefore inflammation of the seminal vesicles, prostate, and testicle may follow. In spite of the dissemination of the organisms throughout the genito-urinary tract, and

accompanying high fever, the general condition of the patient is never comparable with that caused by either a tuberculous or a streptococcal septicaemia. In the two latter diseases the patient clinically demonstrates his hard struggle to live; in the former, in spite of painful symptoms, he shows in face and demeanour that success in the fight is assured.

2.—THE KIDNEY

The kidney is attacked either in its capacity as an excretory organ, or because it has become secondarily invaded by organisms primarily affecting the lower portion of the urinary tract.

In septicaemia the organisms are continuously evacuated from the body by the kidneys, often without obvious harm to the latter, but when the infection is due to the coliform bacillus the chances of this filter being incurably damaged appear to be greater than when infection is due to any other bacteria. The result is chronic pyelonephritis. The term pyelitis should never be used for a blood-borne infection as it conveys an entirely erroneous impression of the pathological process. *Aetiology*

The condition of the patient is one of intermittent ill-health. The urine is loaded with bacilli, but not necessarily with pus. A pure bacilluria is frequent and to the naked eye the urine may appear normal. The presence of pyuria points to a more serious lesion and therefore greater injury to the renal parenchyma. *Clinical picture*

Symptoms referable to the kidney are often so slight as to be considered insignificant by the patient; an occasional backache is the limit of his complaint. The bladder is extremely tolerant of a chronic infection with coliform bacilli and frequency of micturition is the exception rather than the rule. The patient, however, realizes that he is not quite fit, for there is some loss of energy, occasional headache, and transitory elevation of temperature; the latter is an interesting phenomenon in that the rise and fall of temperature may take place within a period of four to eight hours.

Treatment has been until recently unsatisfactory. In the past a large number of drugs have been used as urinary antiseptics though they have no justifiable claim to that description. The excellent papers on this subject by Cuthbert Dukes and Garrod have dispelled many misconceptions about these drugs. The only two which have been found experimentally and clinically to be urinary antiseptics are hexamine and euflavine (neutral acriflavine). Both these substances may be administered either by mouth or intravenously; but if the latter technique is adopted it must be remembered that any foreign material introduced into the blood is excreted by a normal kidney within five minutes of the injection, and that therefore the contact between the antiseptic and the organism is of extremely short duration. Neither of these drugs if administered intravenously will cure a chronic pyelonephritis of *Bacillus coli* origin. Many other antiseptics have been injected into the blood with equally unsatisfactory results. Mercurochrome and eusol *Treatment*

have been tried, but reliance cannot be placed on them to cure the infection. Most of these substances actually reduce the bactericidal power of the blood by inhibiting leucocytic activity. As yet the only drug which, given intravenously, has been proved to increase the anti-bacterial constituents of the blood, is hypertonic saline solution; 100 c.c. of a 20 per cent solution of sodium chloride can be injected daily without fear of damaging the leucocytes.

Hexamine

When hexamine is given by the mouth ammonium chloride or sodium acid phosphate must also be administered in order to ensure that the pH of the urine is maintained at a low level. No organism will be destroyed unless the pH is 6 or less. It is important that the patient shall take these drugs in small doses at frequent intervals, e.g. ammonium chloride 15 grains every four hours followed an hour later by 5 grains of hexamine. Sodium acid phosphate is less irritating than ammonium chloride to the mucous membrane of the urinary tract, but it sometimes causes diarrhoea. Euflavine is less irritating than hexamine, but it is a weak antiseptic. It can be given in doses up to $1\frac{1}{2}$ grains, four-hourly, preferably in keratin-coated tablets.

Renal lavage

Lavage of the kidneys by solution of silver nitrate (1 in 5,000) through ureteric catheters has been popular with many urologists, but may expose the organs to a mixed infection. When the renal cortex is invaded by an organism, irrigation by way of the ureter cannot be expected to purge such delicate structures as the tubules and glomeruli of infection without seriously damaging them. What line of treatment then can combat this chronic infection? The answer is that just as the chronic infection caused by the tubercle bacillus necessitates a mode of life which raises the natural resistance of the body to its highest level, so too does a persisting infection of the kidneys by the coliform bacillus. Plenty of fresh air, with or without sunshine, mild exercise, and good nourishing food are the basic remedial measures as in most cases of chronic ill-health.

*Raising general resistance**Diuresis*

Beside these, forced diuresis is needed to flush bacilli and pus cells out of the tubules, calyces, and pelvis. All the well-known natural waters can accomplish this.

Vaccines

Vaccines have given disappointing results; in fact neither their employment nor that of bacteriophage has been found to be of any value.

Alkalis

Furthermore we have to consider the treatment which aims at the prevention of growth of the bacillus by altering the reaction of the urine. There should not be any difficulty in making the most acid urine alkaline and it must be remembered that the urine of colon bacilluria is strongly acid. The drugs most commonly used are potassium citrate, sodium bicarbonate, and potassium bicarbonate. Potassium citrate alone will never overcome the acidity and it must be given with a bicarbonate. Doses of 20 grains each should be given four-hourly. The amount of alkali should be increased until the urine gives an alkaline reaction, and the treatment should be continued so long as there are any troublesome symptoms.

At the end of a month it is advisable to test the urine repeatedly for evidence of renal irritation, e.g. albumin and casts, for much damage may be done to the lining membrane of the kidney tubule by careless and uncontrolled administration of alkalis over long periods.

In recent years an attempt has been made to cure chronic colon bacilluria by the administration of certain fatty acids with the maintenance of a hyperacid urine. This can be accomplished by the ketogenic diet, so called because its ingestion is followed by excretion of ketone bodies in the urine. An exhaustive survey of this treatment was carried out by David Band, Melville Dunlop, and Lawson Dick in the University of Edinburgh.

The diet used by these investigators contained a minimum quantity of carbohydrate, a small quantity of protein, and a maximum quantity of fat, so that the ratio of glucose to fatty acid was about 1:3. In a number of cases a sterile urine was obtained in periods varying from three to fifteen days after the onset of the ketonuria. If the bacillus is still present one month after the beginning of the treatment it must be considered to have failed. In addition to the diet there should be given 5 grains of ammonium citrate, three times a day.

The chief limitations to this treatment are (1) that it is unsuitable for severely ill and febrile patients, (2) that it demands the services of a skilled dietician, constant clinical observation of the patient, and laboratory control, and (3) that most adult patients show complete intolerance to the drastic restriction of carbohydrates. Children, on the other hand, temporarily flourish on an excess of fat in their diet.

A new line of attack based on the experience gained with the ketogenic diet, but which entirely eliminates the unpleasantness of meals containing an excess of fat, has been investigated recently by M. L. Rosenheim. The effective bacteriostatic factor in the urine of patients on the ketogenic diet, when the pH of the urine falls below 5.5, is β -hydroxybutyric acid. Administration of this substance by the mouth is ineffective since the acid is completely oxidized. A number of other acids which are more stable than β -hydroxybutyric acid have been tried by Rosenheim. It was finally discovered that, in respect of its bacteriostatic powers *in vitro*, mandelic acid compared favourably with any other. Moreover, it is non-toxic to man. In the presence of an acidosis produced by ammonium chloride, the urine, following the administration of mandelic acid, was rendered bacteriostatic, particularly if the pH was 6.2. It is now usual to give the mandelic acid in three or four doses, each of 3 grams, daily. At least 2 grams of ammonium chloride should be given in water immediately after each dose of the acid; the solution may be flavoured with liquid extract of liquorice. Syrup of orange is a suitable flavouring agent for mandelic acid.

In the first twelve cases treated by Rosenheim, the results proved satisfactory and the urine became sterile within a few days after the beginning of the treatment.

Since Rosenheim published his original article in 1935, many observers

have studied the effects of mandelic acid in colon bacilluria. The results to date give greater hopes of possible cure than those of any other treatment, but a warning is necessary in order to control the enthusiasm for a new remedy which at its birth has produced a few striking successes. It must be stressed that sterilization of the urine in this disease is not an indication that the final battle has been won. The mode of entrance of the coliform bacillus into the blood-stream is not known, and therefore, however successful the treatment may be in relieving symptoms referable to the genito-urinary tract, the primary lesion still remains securely out of reach. The mandelic acid treatment has been in use for a relatively short period only. During this period there have been some disappointments in that the organisms in the urine have not been destroyed; but they are not likely to be if the renal tissue has been severely damaged.

*Results of
mandelic
acid
treatment*

In the course of the year 1936 a careful study of the effect of mandelic acid upon *Bacillus coli* infections was made at Whipps Cross Hospital. At the outset it was found that the salts of mandelic acid, namely, sodium and ammonium mandelate, were less effective than the acid itself, with the pH of the urine controlled by ammonium chloride. The method of administration was that described by Rosenheim in his original article, and each course consisted in the administration of the equivalent of 12 grams of mandelic acid daily for ten days, as well as control of the pH of the urine with ammonium chloride. Fifty cases of *Bacillus coli* infection of the kidneys uncomplicated by any pre-existing disease were treated. There were also ten cases of pyelitis complicating pregnancy, and sixteen cases in which a surgical lesion of the urinary tract was present.

In the first category ten of the patients were males and forty females. Their ages varied from six to sixty-nine years. One half of these had been previously treated with alkalis without success. Three had also had cytotropin intravenously without effect. In thirty-four of these fifty cases the urine became sterile and free from abnormal constituents after one course of treatment. In seven cases the urine became sterile after a second course of treatment. Nine remained infected. Thus out of a total of fifty, forty-one were apparently cured.

In the ten cases of pyelitis complicating pregnancy, seven had a normal urine after a ten-days' course of treatment. Two cases did not yield to the treatment, and in one the patient discharged herself before the treatment was complete. In none of these cases was there evidence of damage to the kidneys from the acidity of the urine. Six months previously one of the successful cases had been given alkalis during the early stage of pregnancy without effect.

The results of mandelic acid treatment in the sixteen cases in which colon bacilluria was a complication of a surgical lesion of the urinary tract were disappointing, particularly in those with prostatic obstruction. In cases of lower urinary tract obstruction it is necessary to differentiate between a primary cystitis and one which is secondary

to a chronic pyelonephritis. In the former, given an operation by the most modern technique and no gross changes in the bladder wall, the infection will clear up without any other treatment: in chronic pyelonephritis of back-pressure origin, treatment both by operation and by mandelic acid may fail to clear up the infection. Thus, in fourteen cases of prostatic obstruction with infective pyelonephritis the urine was still infected after a ten-days' course of mandelic acid. Thirteen of these cases had previously been submitted to prostatectomy. The fourteenth had had a cystotomy for complete retention due to chronic prostatitis with calculi; severe bladder strangury and an alarming increase of the haematuria followed the administration of mandelic acid; but within twenty-four hours after this treatment was stopped the strangury had subsided.

In one patient, aged 65, with orchitis complicated by pulmonary embolism and saphenous thrombosis, the urine was still infected after treatment by various compounds of mandelic acid, but with the administration of the acid itself there was certainly a decrease in the amount of pus.

The various treatments which have been so far considered are based on the assumption that the septic process in the kidney is not superimposed upon some pre-existing disease. It is hardly necessary to emphasize the importance of eliminating such a contingency before a decision is reached regarding the line of treatment.

The coliform bacillus is the most common organism to attack a kidney which has been devitalized by hydronephrosis, growth, calculus, or back pressure from an obstruction in the lower urinary tract. It is exceptional, when colon bacilluria is a complication of some disease of the kidney, for the infection to be cured without nephrectomy. This is most noticeable in prostatic obstruction associated with chronic pyelonephritis of *Bacillus coli* origin. The relief of the obstruction removes the back pressure on the upper urinary tract and so restores the renal function to normal, but it does not cause the disappearance of the bacteria. Many of the post-operative complications of prostatectomy are due entirely to continuous spraying of the wound at the neck of the bladder with colon bacilli washed down by urine from the kidneys.

Predisposing factors

3.—THE BLADDER

During an acute attack of *Bacillus coli* cystitis the frequency and strangury may be very severe and often accompanied by haematuria. Investigation by cystoscopy is contra-indicated until the irritation of the bladder has subsided. Treatment consists of rest in bed, a reduction in the normal intake of fluids and the conversion of an acid urine to alkaline by means of potassium citrate and potassium or sodium bicarbonate (see p. 284). Morphine is required to give the patient some respite from the constant painful urge to micturate. When the bladder

capacity has returned to a four-hourly frequency, the urologist should then proceed with his investigation.

Aetiology Cystitis due to the *Bacillus coli* may be caused by a descending infection from the kidney, by direct spread from the large bowel as occurs in diverticulitis, by carcinoma of the bladder, or by the insertion of an infected urethral instrument. The expert cystoscopist can easily determine the source of infection. Carcinoma, diverticulitis, and lesions of the kidney are easily diagnosed by catheterization and pyelography.

A primary *Bacillus coli* cystitis may be the result of a blood-borne infection direct to the bladder or, particularly in women, of the introduction into the urethra of an infected instrument or foreign bodies like slippery elm.

Treatment Treatment of the chronic cystitis depends on the nature of the primary lesion. If the kidneys are infected it is obvious that local treatment for the bladder inflammation is merely meddlesome.

When diverticulitis is the cause, alleviation of the vesical symptoms is only possible with the aid of colostomy. At a subsequent date excision of the vesico-colic fistula may be attempted.

In carcinoma of the bladder, lavage is rarely tolerated in inoperable cases. If the sepsis is profound and secondary haemorrhage is threatening, the patient's misery can be relieved only by a suprapubic cystotomy or transplantation of the ureters.

It is in primary *Bacillus coli* cystitis that local treatment has definite advantages. Irrigation with non-irritating antiseptics, such as solution of potassium permanganate (1 in 5,000) or solution of acriflavine (1 in 4,000) will soon cause the inflammation to disappear provided that catheterization is limited to, at most, twice a week.

4.—THE PROSTATE AND VESICULAE SEMINALES

Aetiology Prostatitis of *Bacillus coli* origin may arise either as a result of an infected urine passing along the prostatic urethra and escaping down the ducts of the gland or as a metastasis in *Bacillus coli* septicaemia.

Symptoms Few symptoms referable to the prostate occur so long as there is no pus formation. The inflammation is never as acute as that observed in gonococcal prostatitis and is not associated with a urethral discharge unless an abscess has formed. Intermittent fever is often present, and the patient very occasionally complains of a dull ache in the perineum and the region of the sacrum.

No local treatment is of any avail unless there is a collection of pus.

Prostatic abscess In all cases of acute colon bacilluria it is important to examine the prostate by the rectum. A tense tender gland denotes abscess formation, which is confirmed by gentle massage causing a urethral discharge.

The metastatic type of prostatic abscess is readily recognized; a patient with pyrexia and no urinary symptoms suddenly complains of burning

pain on micturition and discomfort round the anus on defaecation. This is followed by a urethral discharge. In these cases there is no immediate hurry to evacuate the pus by operation, for a prostatic abscess will often empty itself into the urethra via the prostatic ducts. Delay, however, must not be too prolonged on account of the toxæmia, and if at the end of twenty-four hours the local symptoms have not subsided and the prostate still feels tense per rectum, recourse must be had to a perineal incision.

Under a general anaesthesia, or if preferred evipan sodium anaesthesia, with the patient in the lithotomy position, an incision is made along the line of the median raphe of the perineum, and the point of the knife plunged into the apex of the prostate. To avoid damaging the urethra it is advisable to pass a metal bougie, which acts as a guide for the finger in its approach to the distended prostate. A drainage tube through which the abscess cavity must be irrigated daily with eusol is then inserted and stitched to the skin. As soon as the discharge ceases, this tube can be removed and the patient may then begin taking warm hip-baths.

The prognosis is good with respect to recovery from the acute infection, but a chronic prostatitis will persist for many months. With the passage of years the gland becomes fibrous, necessitating either intermittent urethral dilatation or removal of the scar tissue by operation. This is the ideal case for transurethral resection.

The vesiculæ seminales may be involved in the infection at the same time as the prostate and then one or both testicles will also be attacked.

5.—THE TESTICLE

Inflammation of the testicle begins either as an epididymitis or an orchitis. If the epididymis only is involved the infection has spread from the prostate and seminal vesicle along the vas deferens. The disease, if severe, will extend from the epididymis to the body of the testicle and cause it to slough. In such cases the temperature remains at 104° or even 105° F. There is frequently considerable difficulty in determining by clinical examination whether or not suppuration has occurred, owing to the presence of the strong fibrous covering, the tunica albuginea of the testis. The skin of the scrotum is slightly oedematous but does not present the usual appearance of acute inflammation associated with severe epididymitis. A leucocyte count should always be made. The diagnosis is established by the detection of coliform bacilli in the urine.

Suppuration of the epididymis only is easily recognized for there is extreme tenderness and the skin over it is swollen, red, and adherent. In the presence of a swollen testicle of which the body is enlarged, persistent high fever, and signs of profound toxæmia, the diagnosis of suppuration or gangrene can be made with confidence.

Treatment

Treatment is simple. The sooner the abscess in the testicle is opened and drained the sooner will the suppurative process clean up and the toxæmia subside. If inflammation only is present, expectant treatment is indicated. The patient must be confined to bed and the scrotum supported by a pad of wool. Local applications, such as glycerin of belladonna or lead lotion, should be applied to relieve the pain. Morphine is indicated to induce sleep. Every effort must be made to control the infection in the urinary tract, otherwise there is danger of recurrent attacks of epididymitis.

Orchitis of metastatic origin

Orchitis of metastatic origin is difficult to diagnose unless a positive culture from the blood is obtained, or the *Bacillus coli* is isolated from an abscess in the testicle. The excretion of the organism in the urine is intermittent and therefore it is a matter of luck whether or not it is discovered in a single specimen. The writer recalls the case of an elderly man who was suddenly seized with pain in the right testicle. The patient had developed an orchitis which proved, when suppuration occurred and the pus was bacteriologically examined, to be of *Bacillus coli* origin. No organisms were discovered in numerous specimens of urine. Clinically the orchitis of mumps closely resembles that due to *Bacillus coli* infection.

Treatment is expectant unless suppuration or gangrene occurs, when orchidectomy should be performed.

Prognosis

One of the most unfortunate results of a *Bacillus coli* infection of the body of the testicle is the loss of function. The place of the interstitial cells is gradually taken by fibrous tissue and in course of time the whole organ atrophies.

6.—*BACILLUS COLI* INFECTIONS IN THE FEMALE

In the pyelonephritis of pregnancy (see also PREGNANCY, DISEASES OF) symptoms are in the majority of cases referred to the right kidney, but in quite a large proportion the infection is bilateral. Treatment should be the same as in the male. In some cases the symptoms may be extremely severe. High fever, bladder strangury, and hæmaturia will cause the patient intense discomfort and loss of sleep. Even under such conditions miscarriage does not occur. Morphine should be given at frequent intervals while the acute attack lasts, not only for the relief of pain but also to induce sleep.

The one danger in the pyelitis of pregnancy is that of instrumental interference. With a prolongation of symptoms and fever there is a tendency for the patient, relatives, and doctor to tire of masterly inactivity and there comes a demand for more active measures than the mere temporary relief afforded by drugs. Ureteral catheterization is often of great value in cases of complete blockages, but in the absence of such a special indication this procedure and lavage of the renal pelvis cannot be too severely condemned. More than one patient as a result

of this treatment has lost not only her kidney, but also her unborn child. It is remarkable how the pregnant woman can weather the storm of acute colon bacilluria without permanent damage either to herself or her infant.

After confinement the bacilluria and pyuria may persist, though usually they disappear, in which event recurrence at a later date with or without a further pregnancy is the rule rather than the exception. The symptoms in such cases are mild, the patient complaining of slight malaise and increased frequency of micturition. If she has had many similar attacks she should be instructed to take large doses of alkali at the outset. In this way an attack is often aborted. A similar result may be expected with mandelic acid. *Prognosis*

Cystitis in the female at all ages is extremely common, in fact experience shows that woman is much more susceptible to the depredations of the *Bacillus coli* in the urinary tract than is man. On the other hand the sexual organs are rarely affected, ovaritis and salpingitis due to this organism being unusual. When it does occur the medium of conveyance is the blood. *Cystitis*

If hyperpyrexia and severe abdominal pain are present exploratory laparotomy will be needed to establish the presence of pus.

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COLITIS

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Reference may also be made to the following titles:

AMOEBIASIS	DYSENTERY, BACILLARY
COLON, CARCINOMA OF	MUCOUS COLIC
DIVERTICULOSIS AND	
DIVERTICULITIS	

1.—DEFINITION AND NOMENCLATURE

250.] The term colitis should be used only to describe conditions in which the colon is inflamed. Unfortunately it is much more frequently applied to purely functional abdominal disorders occurring in neurotic patients. In many cases there is no excuse for this, a patient being told he has colitis in order to satisfy his craving for a name to attach to his vague abdominal discomforts. Frequently the presence of mucus in the stools is regarded as evidence that the mucous membrane of the colon is inflamed and 'mucous colitis' is diagnosed. When no mucus is passed under natural conditions a patient is often sent to a 'colon laundry', where towards the end of an intestinal lavage with 20 or 30 pints of fluid the irritated mucous membrane at last responds by secreting mucus, which is shown to the gratified patient, who is told that it must have been present for weeks or months to have required so much water to dislodge it!

The mucous membrane of the colon, like every other mucous membrane, secretes mucus in response to irritation. The majority of the cells lining the crypts of Lieberkühn in the healthy colon are goblet cells, and their ability to secrete mucus in response to mechanical and chemical irritation is a sign of their normal functional activity. The faeces which collect in the pelvic colon are often dry and hard; mucus is secreted, with the result that the scybala are covered with a thin layer of mucus, which facilitates their smooth passage through the rectum and the narrow anal canal. When a purgative is taken the mucous membrane secretes mucus which protects it from damage. The drug acts by irritating the mucous membrane and thus initiates a local reflex leading to increased motor activity. Consequently the loose stool which is passed often contains excess of mucus. Enemas of all kinds, but especially those containing irritants, such as soap, glycerin, turpentine, potassium permanganate, and silver preparations, also cause increased secretion of mucus.

*The secretion
of mucus
by the colon*

The sticky mucus secreted by the goblet cells of the colon picks up minute particles from the surface of the mucous membrane (Florey). It is then rolled into small masses by the activity of the muscularis mucosae and expelled with the faeces. Consequently the mucus normally secreted in response to irritation contains epithelial debris (which is constantly being shed by the mucous membrane) and the bacteria which normally inhabit the colon, but their presence, unlike that of leucocytes, red corpuscles, or pathogenic organisms, is not an indication of inflammation or infection. The sigmoidoscope also shows that the mucous membrane is perfectly healthy in appearance.

The discovery of mucus in the stool is widely regarded as evidence that 'mucous colitis' is present, and mucous colitis is consequently believed to be a very common disease, whereas the presence of mucus with a formed stool, or with an unformed stool when an aperient has

been taken or an enema given, is really evidence that the mucous membrane is healthy and capable of protecting itself from damage by mechanical and chemical irritants.

When excess of undigested food reaches the colon as a result of the rapid passage of food through the small intestines in enteritis, the colonic mucous membrane may respond to the irritation by secreting excess of mucus, although no colitis is present.

*Significance
of mucus
in the stools*

It is clear, therefore, that the presence of mucus in the stools can justify the diagnosis of colitis only when the mucus is passed with unformed stools by a patient who is not taking aperients and who is not suffering from enteritis.

*'Mucous
colitis'*

The term 'mucous colitis' should never be employed, first because the presence of mucus does not indicate that the colon is inflamed, and secondly because mucus is always secreted in excess when true colitis is present, so that the addition of the word 'mucous' is superfluous when it is not misleading. For so-called muco-membraneous colitis, which is a nervous disorder of the colon in which there is no evidence of inflammation, see MUCOUS COLIC.

2.—NON-ULCERATIVE COLITIS

*Sequel to
irritation*

Long-continued irritation of the kind described in the previous section may eventually give rise to a true catarrhal colitis, in which mucus continues to be passed for a time after the use of the aperient or other irritant has been discontinued. In such cases the mucus contains excess of desquamated epithelial cells but no pus cells, and the sigmoidoscope shows that a mild degree of inflammation is present. Rapid recovery occurs when the cause is removed. A non-residue diet should be given and the stools should be kept soft by means of liquid paraffin and an unirritating vegetable mucilage such as coreine (see CONSTIPATION, p. 383).

*Provoked by
'roughage'
in food*

A similar mild catarrhal colitis may result from the long-continued use of excess of 'roughage' in the food, to which are sometimes added such things as bran and psyllium seeds, which may be good for birds but are certainly most unsuitable for human beings. Psyllium seeds with their sharply pointed ends can be found almost unaltered in the stools of patients who are taking them for constipation. Here again the substitution of an unirritating diet and an unirritating vegetable mucilage for irritant products will result in rapid recovery.

The toxins present in bad food, poisons such as arsenical and mercurial compounds, and toxins excreted into the alimentary tract in acute infections (such as gastric influenza and septicaemia) and in uraemia, may cause acute non-ulcerative colitis, which is often associated with acute gastritis and enteritis. The diarrhoea resulting from the colitis forms only a part of the clinical picture of these conditions, which are described in detail in other sections.

3.—ULCERATIVE COLITIS

(1)—Aetiology

The main incidence of chronic ulcerative colitis is between the ages of 21 and 40. The disease is rare in children, in whom it tends to be particularly fatal. The sexes are about equally affected.

(2)—Pathogenesis

In his description of the morbid anatomy of sporadic cases of chronic bloody flux occurring in England, Wilks (1875) referred to the disease as ulcerative colitis, a name which has been adopted in Europe and America for this condition, but he pointed out that it was anatomically indistinguishable from dysentery. During the War I had frequent opportunities at Lemnos and at Salonica of sigmoidoscopy patients with dysentery. I recognized at once that amoebic dysentery presented a characteristic picture which bore no resemblance to that of bacillary dysentery, but it was impossible to distinguish the latter from the ulcerative colitis with which I was already familiar in England. This question is further discussed on p. 298.

Bacillary dysentery, the 'bloody flux', has been endemic in England since the fourteenth century, and the mild and scattered epidemics which are still common in country districts and in institutions are the direct descendants of the serious and widespread epidemics of the seventeenth and eighteenth centuries, reinforced by infection brought home by soldiers from the Crimean and South African Wars, and the Great War, and recently by passengers on pleasure cruises.

Eyre in 1904 was the first to prove that asylum epidemics were caused by *B. dysenteriae*, and Nabarro in 1912 found that many cases of summer diarrhoea in small children, as well as cases diagnosed as chronic colitis, are caused by the same organism. Since then it has been proved that small epidemics of true dysentery are of frequent occurrence not only in asylums and other institutions, including schools, but also in country districts.

I believe indeed that if all cases of acute diarrhoea occurring in England, however short in duration, and especially those in which blood as well as mucus is present in the stools, were examined bacteriologically, bacillary dysentery would be found to be much less rare than is generally believed. Many cases of acute diarrhoea are of such short duration that they are not seen at all by a doctor. In others the stools are not kept for his inspection, and it must be comparatively rare for a bacteriological examination of the stools to be carried out in an attack which does not last for more than a few days.

The only case of the kind which I have had the opportunity of investigating was in a boy of sixteen at a public school. There were no other cases of diarrhoea, and there was no history of recent contact with anybody suffering from a similar complaint. I saw him on the morning of the third

*Relation to
bacillary
dysentery*

*Isolation of
B. dysen-
teriae*

day of his illness; he had a high temperature, his stools contained large quantities of blood with pus and mucus, and the appearance with the sigmoidoscope was typical of ulcerative colitis. Flexner's bacillus was isolated from a stool passed on the first day. He was given 40 c.c. of anti-dysenteric serum intravenously and recovered completely within a fortnight. There has been no recurrence in the eight years which have since elapsed.

It is quite common in ordinary cases of chronic ulcerative colitis to obtain a history of an acute onset of an illness exactly resembling acute dysentery. The first acute attack often lasts only a few days and a doctor may never have been consulted, but the spontaneous recovery is followed by one or more relapses, one of which finally passes into the chronic condition of ulcerative colitis. Such patients generally come into a hospital where thorough bacteriological investigation of the stools and sigmoidoscopic swabs are carried out only after they have been ill for many months or even years, by which time it is not unnatural that the original infection has died out or has become so attenuated that it is very likely to escape recognition unless many successive examinations are made.

*Isolation of
B. dysen-
teriae from
stools*

In chronic dysentery arising in hot climates it becomes increasingly difficult to cultivate the *B. dysenteriae* from the faeces as time goes on. I have seen three cases in which the history was typical of ulcerative colitis and the sigmoidoscopic appearance of the bowel was quite indistinguishable from that seen with the common type of the disease as it occurs in England, yet the discovery of Flexner's bacillus soon after the acute onset in Salonica, Gallipoli, and India respectively showed that the condition could equally well be regarded as chronic bacillary dysentery when the patients came under observation two, five, and nineteen years later respectively. In the first Flexner's bacillus was still present, in the second it had not been isolated since the original illness, and in the third it had last been isolated ten years earlier.

*Isolation
from ulcer*

In 1923 Dudgeon isolated Flexner's bacillus in two cases of ulcerative colitis from material obtained from the surface of an ulcer examined through a sigmoidoscope. The bacillus was isolated by Thorlakson and Cadman of Winnipeg in 1928 in six out of nine cases from material obtained by scraping the base of an ulcer with a sharp curette, though they had never before discovered it in stools or in ordinary swabs from the surface of the ulcer. In 17 (i.e. 20 per cent) of 83 consecutive cases of ulcerative colitis investigated by Mackie in New York, dysenteric organisms were isolated from swabs obtained through the sigmoidoscope. In many instances frequent cultures had to be made over a considerable period before a positive result was obtained; in one case cultures were made through the sigmoidoscope weekly for eighteen weeks before a dysenteric bacillus was recovered. In a control series of 102 patients without ulcerative colitis a dysenteric bacillus was isolated in 2, but both were suffering at the time from acute diarrhoea.

*Isolation
from swabs*

*Examination
of controls*

In 1930 Knott isolated Flexner's bacillus, which was agglutinated by the patient's serum, from a swab obtained from the raw surface left after I had snared a polypus in the rectum of a woman, aged 36, who had had very severe ulcerative colitis since 1925, although numerous examinations of stools and swabs taken from ulcers during the five years of her illness had only shown *B. coli* and enterococci. Since then he has isolated Flexner's bacillus from sigmoidoscopic swabs in five other cases of mine, Flexner variants in two and Sonne's bacillus in one. None of these patients had ever been abroad or had been associated with anybody known to have had dysentery. Three of the Flexner cases, the Sonne case, and the two Flexner variants were in the New Lodge Clinic series of forty patients.

In addition to the various strains of definite dysenteric bacilli a number of other organisms not found in the normal colon were isolated by Knott from sigmoidoscopic swabs obtained from patients with ulcerative colitis. In Table I he has classified the whole series according to their probable pathogenicity.

TABLE I.—Bacteria other than *B. coli communis* and Enterococci isolated from Faecal Cultures (McConkey and Blood Agar Plates), from Consecutive Series of 40 Cases of Ulcerative Colitis (F. A. Knott)

A. Pathogenic dysenteric strains

<i>B. dysenteriae</i> (Flexner)	—	—	—	—	3 cases
<i>B. dysenteriae</i> (Flexner); late lactose fermenting variants					2 cases
<i>B. dysenteriae</i> (Sonne)	—	—	—	—	1 case

B. Pathogenic parenteric strains

<i>B. enteritidis</i> (Gaertner)	—	—	—	—	1 case
<i>Salmonella morgani</i>	—	—	—	—	7 cases
<i>B. asiaticus</i>	—	—	—	—	4 cases

C. *B. coli* variants and other coliform strains of doubtful pathogenic power

'Paracolon' bacilli	—	—	—	—	2 cases
<i>B. coli haemolyticus</i>	—	—	—	—	1 case
<i>B. faecalis alkaligenes</i>	—	—	—	—	1 case
<i>B. Friedländer</i>	—	—	—	—	4 cases

D. Proteolytic strains of possible secondary pathogenic power

<i>B. proteus</i>	—	—	—	—	5 cases
<i>B. pyocyaneus</i>	—	—	—	—	2 cases

E. Virulent micrococci

<i>Streptococcus haemolyticus</i>	—	—	—	—	1 case
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Two or more organisms were often isolated at the same or at different times in one patient.

According to Bargaen (1924) a Gram-positive 'diplostreptococcus' is the cause of ulcerative colitis. A large majority of American bacteriologists and all who have studied the subject in England agree, however, that this organism is simply a variant of the normal enterococcus

Bargaen's
diplostrepto-
coccus

Strains of
B. dysen-
teriae

present in all stools, and that it is found quite frequently in the faeces of healthy individuals. According to Brown and Paulson, 'there has not been a single unquestioned confirmation (of Barga's work) published to date (1929)'. Paulson isolated 10 types of streptococci from 14 cases of ulcerative colitis during acute exacerbations; no one type was present in more than 3 cases, and Barga's diplococcus was isolated in 2 only. Seven of the 10 types were injected intravenously into rabbits: 5, including Barga's organism, produced lesions in the colon, 3 of them in 45 per cent of animals compared with 16 per cent with Barga's organism. Other organisms from various sources produced identical lesions. These experiments show that Barga's claim that his organism produced specific lesions experimentally cannot be sustained. The relative excess of cocci often found in the stools in ulcerative colitis is due to the fact that streptococci of all kinds thrive in the presence of mucus, blood, and pus.

Gallart Mones and Dimingo Sanjuan (1935), using precisely the same technique as Barga, isolated his diplostreptococci in 32 per cent of cases of ulcerative colitis and in no less than 25 per cent of normal controls. They also found that Barga's organism did not produce intestinal lesions more frequently in rabbits than did any of the five other strains of streptococci which they isolated from cases of ulcerative colitis, but they noted that all varieties of streptococci and their filtrates obtained from the stools in ulcerative colitis were more toxic than the corresponding strains and their filtrates obtained from the stools of healthy individuals.

Knott has found Barga's organism in some of my cases of ulcerative colitis, but he has also found it with abnormal frequency in cases of diarrhoea without colitis and often in the normal stools of healthy individuals. Our experience therefore agrees with that of nearly all independent observers, i.e. that Barga's diplococcus is nothing more than a variant of the enterococcus found in normal stools and that it does not play a part in the pathogenesis of ulcerative colitis.

Conclusion

The identical morbid anatomy, the occasional isolation of a dysentery bacillus, and perhaps the response of some cases, especially those in an early stage, to specific treatment with antidysenteric serum confirm the view which was first expressed by Saundby (1906) and by Hawkins (1907), and which I have consistently held since the War, that ulcerative colitis is a form of bacillary dysentery. In the majority of cases the primary infection is probably with a dysentery bacillus or perhaps in some cases an allied parenteric organism. In many cases a secondary infection occurs. This may be with (1) parenteric organisms, some of which are normally non-pathogenic or only slightly pathogenic; these might pass through a healthy colon without causing damage but may multiply in the abnormal contents of the ulcerated colon; (2) the normal bacteria (*B. coli* and enterococci) of the colon, which may develop toxic properties as a result of the excess of soluble protein and the blood and pus in the medium surrounding them; (3) streptococci derived

from the throat as a result of an incidental attack of tonsillitis. It is a common experience for relapses to occur as a result of food poisoning, perianal infection, and acute infections of the throat.

The condition of the colonic mucous membrane may also be aggravated as a result of malnutrition from a too restricted diet, especially one containing insufficient vitamins, and as a result of the anaemia following continued loss of blood, particularly if the food is also deficient in iron. Possibly in some cases exacerbations are caused by allergy in patients who are sensitive to certain food proteins or other substances. *Predisposing factors*

(3)—Clinical Picture

The onset is sometimes acute with severe diarrhoea and fever, but this is often followed by a quiescent period before the condition becomes chronic. In other cases the onset is subacute and insidious, the first symptom noticed being the passage of blood and mucus with or without diarrhoea. Even in cases which appear to begin acutely a history can often be obtained of slight intestinal irregularity, with the occasional passage of mucus or blood, for many months before the onset of severe symptoms. *Onset*

Diarrhoea is always present; as many as twenty stools, most of which are quite small, may be passed in the day. Blood, pus, and mucus are passed with unformed faeces; in quiescent periods they may appear to be absent, but microscopical examination of the stools shows that this is not the case. Blood may be passed in large quantities and alone, but it is generally mixed more or less intimately with the mucus and pus. It is bright red, and never produces black tarry stools, such as are seen with gastric and duodenal ulcer. It is mostly fluid, but small clots are often present. The mucus is clear or opaque from the presence of pus; membranes are never passed. In most cases small collections of pus are easily recognized with the naked eye in addition to that mixed with the mucus and faeces. *Character of faeces*

Abdominal discomfort is often, but not always, present. Actual pain is rare except immediately before defaecation, when colic may occur; this disappears as soon as the bowels are opened, especially if flatus is passed. Tenesmus is unusual and only occurs if the anal canal is involved. The abdomen is sometimes slightly distended, but in many cases it is retracted. Tenderness is often completely absent even in severe cases, but pressure over the colon, especially in the left iliac fossa, may cause discomfort. Persistent and extreme tenderness indicates that the inflammation has spread to the peritoneum and that pericolicitis is present. A moderate degree of muscular rigidity is often found in severe cases, especially when there is any local peritonitis. *Pain*

(4)—Complications

No example of stricture formation or polyposis was recorded among the cases collected from the post-mortem records of the London

hospitals for the discussion at the Royal Society of Medicine in 1909. At that time a large proportion of cases were fatal, and a definite diagnosis was not often made during life owing to ignorance of the clinical picture. Radiology had not yet been introduced as a method of investigating suspected cases of colitis, and the value of sigmoidoscopy was mentioned by Lockhart-Mummery for the first time in any discussion on the subject. Consequently systematic treatment was rarely instituted, and few patients were kept alive sufficiently long to develop the various complications which have only recently become well recognized.

Table II gives the frequency of the complications occurring among 693 cases treated at the Mayo Clinic (Bargen, 1929), and forty cases at New Lodge Clinic. In many instances two or more of the complications occurred in the same individual.

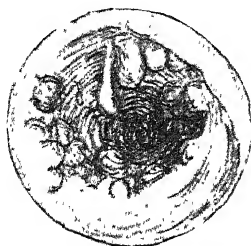
TABLE II.—Frequency of Complications in 693 Mayo Clinic and 40 New Lodge Clinic Cases

		MAYO CLINIC		NEW LODGE CLINIC	
		TOTAL	PERCENTAGE	TOTAL	PERCENTAGE
Polyposis	—	69	10	5	12.5
Strictures	—	59	8.5	5	12.5
Arthritis	—	30	4	1	2.5
Fistula in ano and perirectal abscess		26	4	5	12.5
Perforation	—	23	3	0	..
Cutaneous lesions	—	17	2.5	1	2.5
Cancer of the rectum or colon		15	2	0	..
Nephritis	—	8	1	1	2.5
Endocarditis	—	7	1	0	..
Ocular disease	—	5	1	1	2.5
Mesenteric thrombosis	—	3	0.5	0	..
Thrombophlebitis	—	..	..	1	2.5

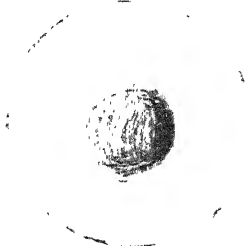
(a) *Polyposis*

The first reference to polyposis of the colon as a complication of ulcerative colitis appeared in the *Guy's Hospital Reports* for January 1925 (Ive). Since that time polyposis has become recognized as a common sequel of partial or complete healing in very chronic cases, the actual incidence being about 10 per cent. The polyps form as healing occurs. Most are composed of mucous membrane, containing much inflammatory and granular tissue, but occasionally true adenomas develop. This has been proved by microscopical examination in several of my cases and also at the Mayo Clinic. Of the five New Lodge Clinic cases four were multiple (see Figs. 32, 33, and 34), and one was single,

situated ten inches from the anus. One of the former was associated with a large polypoid granuloma, which closely resembled in its sig-



(a)



(b)

FIG. 32.—Male, 23. (a) Stricture and polyposis 2½ years after onset of ulcerative colitis; (b) six months later, after destruction of polypi by diathermy cautery; fibrous stricture still present, but causing no symptoms. (*Guy's Hospital Reports, 1935*)

moidoscopic appearance a carcinoma of the rectum (see Fig. 34). The polypi are readily recognized with the sigmoidoscope, but they must be distinguished from the tags of mucous membrane which are occasionally left as islands in extensive areas of ulceration. Their distribution through the colon can be recognized with the X-rays (see Figs. 35 and 36).

Polypi may give rise to haemorrhage after recovery from the colitis, and they may also form foci of infection which may be the starting-point of a recurrence. In a few of my cases multiple small polypi have completely disappeared with deep X-ray treatment (Kingsbury), but radiotherapy should not be used until the primary ulceration has healed, or the inflammation may be aggravated. As the polypi may become malignant, and as they may also give rise to haemorrhage or form a focus from which re-infection may occur, they should be removed or destroyed as completely as possible by a diathermy cautery through a proctoscope or sigmoidoscope (see Figs. 32 (a) and (b)). If very numerous and widespread it may be necessary to perform a colectomy in addition (see p. 315).

(b) Carcinoma

Carcinoma may develop as a result of malignant degeneration of an adenomatous polyp arising as a complication of ulcerative colitis, though the large

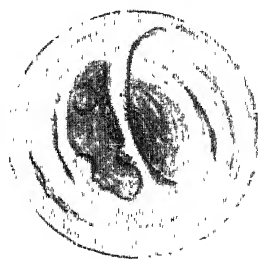


FIG. 33.—Male, 28. Ten years after recovery from serious ulcerative colitis, showing polypi, a band of mucous membrane bridging over rectal lumen and slight fibrous stricture. The bridge was removed and the polypi were destroyed by diathermy cautery. (*Guy's Hospital Reports, 1935*)

Treatment of polyposis

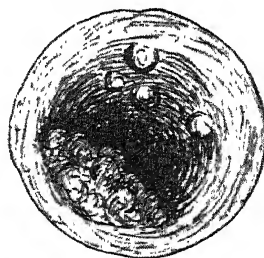


FIG. 34.—Female, 52. Granulomatous mass and polypi, later destroyed by diathermy cautery. (*Guy's Hospital Reports, 1935*)

Incidence

majority of adenomas which become malignant are not secondary to any form of colitis. Fifteen such cases occurred in the Mayo Clinic series: many were in young individuals and the carcinomas were always of a high degree of malignancy. I have seen three such cases,



FIG. 35.—Female, aged 56. Polyposis throughout the colon
(*Guy's Hospital Reports*, 1935)

none of which is included in the New Lodge Clinic series. In one the growth developed three years after complete recovery from the ulcerative colitis. The second patient was a woman of 50 who had been ill for several years; active ulcerative colitis, multiple polyposis and a carcinoma of the rectum were all present together when I first saw her a fortnight before her death from exhaustion.

sloughing ulcers. This complication occurred together with iritis in one New Lodge Clinic case, when it appeared to be trophic in origin and the result of vitamin-deficiency in an anaemic patient suffering



FIG. 37.—Female, aged 21. Radiogram taken after combined opaque meal (given 96 hours earlier) and opaque enema; it shows the enormously dilated ileum, caecum, and ascending colon, which were still filled 4 days after the opaque meal had been given. There was a long stricture at the hepatic flexure and the whole of the transverse colon was replaced by a tube of very small lumen with irregular outline; a short stricture half-way down the descending colon was sufficiently narrow to obstruct the opaque enema almost completely. In spite of 96 hours' stasis in the proximal colon, severe haemorrhagic diarrhoea was present. The patient recovered completely after an ileo-sigmoidostomy followed 6 years later by partial colectomy. (*Guy's Hospital Reports*, 1935)

from a severe infection. Pellagra may also occur in patients receiving *Pellag* an inadequate diet.

(g) Ocular Complications

Crohn (1925) has described the occurrence of conjunctival and corneal inflammation as a result of vitamin deficiency in patients with

ulcerative colitis, who had for long periods been kept on too strict a diet, and I have seen one such case. The condition is similar to the xerophthalmia observed in Central Europe during the War, and in famines in India, as a result of deficiency in fat-soluble vitamin A. Local treatment has no effect, but rapid improvement follows a change to an adequate diet (see DIETETIC DEFICIENCY DISEASES).

(h) Arthritis

Incidence

Prognosis

Multiple arthritis, very similar to acute rheumatism, except that it does not respond to treatment with salicylates, is a well-recognized complication of bacillary dysentery, and it occurred in 4 per cent of the Mayo Clinic cases of ulcerative colitis. I have only seen it once in about a hundred cases. It was accompanied by high fever and affected numerous joints in succession for short periods. The attack lasted about three weeks, leaving the joints free from deformity and with perfect freedom of movement.

(i) Circulatory Complications

Suppurative pylephlebitis

Mesenteric thrombosis

Infective endocarditis

Suppurative pylephlebitis might be expected to be a common complication, but it occurred in one only among 1,200 cases at the Mayo Clinic, and I do not know of such a case recorded in England. Mesenteric thrombosis occurred as a rare complication in the Mayo Clinic series, and I have seen one case with recurrent thrombophlebitis in the veins of the legs. Infective endocarditis is another rare complication.

(5)—Prognosis

Mortality among hospital patients

Mortality in private practice

In the discussion on ulcerative colitis held at the Royal Society of Medicine in 1909 it emerged that no less than 141 (i.e. 50 per cent) of 288 cases collected from the records of seven London hospitals died in hospital. The ultimate mortality was presumably greater. Recent statistics have shown a smaller death-rate. Thus Hern (1931) gave the mortality in Guy's Hospital of 50 cases between 1917 and 1926 as 28 per cent; since an additional 12 per cent died within a comparatively short time of their discharge, the total mortality was 40 per cent. Hardy and Bulmer (1933) recorded 31 deaths among 95 patients in the General Hospital, Birmingham, between 1920 and 1932, a mortality of 33 per cent. The mortality was highest in the first year of the disease and thereafter diminished rapidly with every year of survival.

All these statistics are for hospital patients. The mortality among patients seen in private practice, especially when they have had the advantage of institutional treatment, is very much less (Table III). Thus 7 out of 35 patients seen by Spriggs at Ruthin Castle (i.e. 20 per cent) died either while there or in the two to twenty years which elapsed since their admission. But of these, two received no treatment whilst at Ruthin and three were hopeless on admission; the two former at least should be excluded, which would reduce the mortality

to 12 per cent. Forty patients with ulcerative colitis were admitted into New Lodge Clinic between 1921 and 1934. None died in the Clinic, although in the large majority the disease was of a severe character, and only three have died since leaving it, in each case as a direct sequel of operation. I believe that the mortality should not exceed 5 to 10 per cent if patients receive adequate treatment for sufficient periods. As Hardy and Bulmer point out, there are few diseases in which a patient can reach such a state of emaciation and exhaustion and yet recover.

TABLE III.—Total Mortality in Private and Hospital Patients

	TOTAL DEATHS		PERCENTAGE
New Lodge Clinic and Ruthin Castle	75	10	13.3
Guy's Hospital, and General Hospital, Birmingham	144	51	35

A large majority of patients with ulcerative colitis, however severe, should eventually recover so completely that they are able to lead a life of normal activity. *Prospects of recovery*

There is a great tendency to recurrence, but as time goes on, especially if each recurrence is treated by complete rest in bed and by whatever other measures appear necessary from the earliest possible moment until the clinical evidence and endoscopic examination show that all traces of active disease have passed, the recurrences become milder and more infrequent until finally they cease. Relapses tend to occur with acute infections, especially tonsillitis, food-poisoning, dietetic indiscretions, exposure to cold and damp, and, much less frequently, worry, and fatigue from mental or physical overwork. *Relapses*

If the first attack, which is often nothing else than an acute attack of dysentery, is thoroughly treated at its onset and treatment is continued for sufficiently long, relapses are unlikely to occur. If a patient first comes under treatment after he has already been ill for months or years, recovery is always very slow, and a year or more may elapse before he is able to return to activity. For the next few years relapses are very likely to occur; but it is astonishing how complete the recovery may ultimately be in spite of the presence of severe organic complications, such as multiple strictures and polyposis. The appearance of the colon when examined after an opaque enema may show a complete disappearance of the normal outline, and yet the patient may have been free from diarrhoea and other symptoms for years. In such cases the mucous membrane when examined with the sigmoidoscope may be quite healthy, or it may show the presence of scars and occasionally of polypi or a stricture extending to the lower end of the pelvic colon or to the rectum itself. The latter may prevent the passage of an instrument at more than a very short distance.

In the following table I have adopted the classification used by

Spriggs in his analysis of the Ruthin Castle cases, which include 13 of chronic ulceration after amoebic dysentery in addition to 35 of ulcerative colitis, and have added the New Lodge Clinic series of 40 cases of ulcerative colitis.

TABLE IV.—Cases of Ulcerative Colitis who received some Form of Treatment whilst at Ruthin Castle or in New Lodge Clinic, from Twenty Years to One Year ago

		RUTHIN CASTLE	NEW LODGE CLINIC	TOTAL	PERCENTAGE
Well and 'carrying on'	—	34	32	66	77.6
no relapses	—	21	17	38	
relapses, but recovered from them	—	13	15	28	
Not well, but 'keeping better and about'		5	4	9	10.6
Ill	—	1	1	2	2.4
Dead	—	5	3	8	9.4
Total	—	45	40	85	100

(6)—Diagnosis

(a) Radiological Examination

*Absence of
haustration*

The absence of haustration in a radiogram taken after an opaque enema is a characteristic feature of ulcerative colitis, and its distribution is an indication of the extent of the colitis. The usual explanation is that the inflammation has involved the muscular coat, which is so much damaged that it can no longer form the normal haustra. This theory is, however, untenable, as in the majority of cases the inflammation never spreads beyond the submucous tissue. I have no doubt that the disappearance of haustration is due to paralysis of the muscularis mucosae, which is involved in the inflammation of the submucosa. It has also been stated that when haustration has once disappeared it never returns, and that its disappearance is therefore evidence of permanent and irrevocable organic change. I believe, however, that the disappearance of haustration is of far less serious import than has been generally taught, as it does not indicate that the inflammation has spread deeply, and the muscularis mucosae may be paralysed but not destroyed. Fig. 38 (a) shows complete absence of haustration in a girl aged 19 years who had been suffering from severe ulcerative colitis for three years. Fig. 38 (b) is a radiogram taken two years later; the patient had completely recovered and the haustration had reappeared. In very chronic cases in which the inflammation has spread more deeply than usual and has lasted for many months or even years, a few strictures may develop with permanent disappearance of haustration.

*Reappearance
of
haustration*

In very mild cases of haemorrhagic colitis, in which the sigmoidoscope shows that the blood is associated with minute petechiae but no actual ulceration, haustration is unaffected, as the submucous tissue is not involved and the muscularis mucosae is consequently not paralysed.

(b) *Endoscopy*

An examination should always be made with a long proctoscope; in the rare cases in which the rectum is healthy a sigmoidoscope must be used. An anaesthetic is never required, and if the instrument is carefully

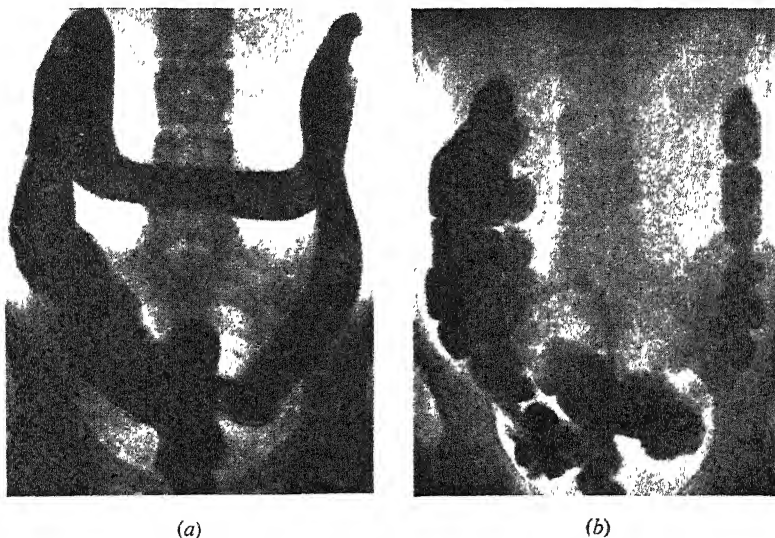


FIG. 38.—(a) April 1934. Radiogram after barium enema of colon of a girl of 19 with three years' history of severe ulcerative colitis. Shows complete absence of haustration. (b) July 1936. Same case as (a) after complete recovery. Radiogram after barium enema shows return of haustration and lengthening of transverse colon, which is no longer in a state of spasm

introduced under visual guidance without inflation and only as far as it goes without difficulty there is no danger.

The mucous membrane is bright red, thick, and sometimes granular. It bleeds very readily when touched, and small submucous haemorrhages are frequently seen. Its surface is covered with blood-stained purulent mucus, some of which should be removed on a sterile swab for bacteriological and cytological examination.

Superficial ulcers are invariably present; but in early cases they may be so small that they are difficult to recognize without a magnifying eyepiece. Later they are large, and sometimes so extensive that only small islets of mucous membrane are left, which may feel like small, flat polypi on rectal examination, the floor of the confluent ulcers being taken for the surface of the mucous membrane. The ulcers are superficial with irregular edges; the thick mucous membrane is

*Appearance
of mucous
membrane*

*Appearance
of ulcers*

occasionally undermined. The floor of the ulcers appears greyish-yellow when the blood and mucus have been wiped from their surface.

(7)—Differential Diagnosis

*From
amoebic
dysentery*

The symptoms of chronic amoebic dysentery are so similar to those of ulcerative colitis that the latter is likely to be diagnosed unless there is a clear history of the illness having originated in some country where the former is endemic. It must, however, be remembered that recurrences may appear months and even years after the original infection. Moreover, cases sometimes occur in individuals who have never been out of England; it may be possible to trace the source of infection, but more frequently the patient does not seem to have been near anybody who has suffered from amoebic dysentery or is likely to be a carrier. I have seen four such cases, and in each the patient had not unnaturally been regarded as suffering from ulcerative colitis. They had been under treatment for many months without improvement, but the recognition of the true nature of the disease and the subsequent injection of 1 grain of emetine hydrochloride every night for twelve nights invariably resulted in rapid and complete recovery.

The sigmoidoscopic appearance in amoebic dysentery is characteristic: in the early stage it is like that of a boil on the skin, a small round red lump with a yellow necrosed centre being seen on a normal mucous membrane. The necrotic area finally sloughs and pus is discharged from the submucous abscess. In the later stages the ulcer increases in size, but the red edges are always raised above the surface of the healthy mucous membrane, in striking contrast with the shallow ulcers without any thickening at the edge and the surrounding red and swollen mucous membrane of bacillary dysentery and ulcerative colitis.

In amoebic dysentery the caecum and ascending colon are often tender and there may be tenderness over the liver owing to associated hepatitis. The proximal part of the colon is generally the first to be affected, in contrast with bacillary dysentery and ulcerative colitis in which they often escape entirely and the distal colon and rectum are the first to be involved.

Theoretically the diagnosis should depend upon the discovery of the *Entamoeba histolytica* or its cysts in the stools, but in two out of the four patients mentioned above they were not found on repeated examination, although the ulcers were typical of amoebic dysentery and rapid and complete recovery followed treatment with emetine.

*Diagnosis of
regional
ulcerative
colitis*

In rare cases there is no sigmoidoscopic evidence of ulcerative colitis, although the patients have the characteristic symptoms and a barium enema reveals the presence of ulcerative colitis involving isolated segments of the more proximal part of the colon. In such cases the diagnosis from amoebic dysentery or tuberculosis of the colon is difficult, as in both a similar distribution may occur.

*From
haemorrhagic
proctitis*

Haemorrhagic proctitis, an ill-defined condition, must be distinguished from ulcerative colitis confined to the rectum, as it may be in its earliest

stages and occasionally in the last few weeks before recovery is complete. The symptoms are indistinguishable from those of mild ulcerative colitis, but the patient is never very ill and is often well enough to lead an active life in spite of the frequent passage of loose stools containing blood with or without mucus and pus. The proctoscope shows innumerable minute bleeding erosions in a normal or almost normal looking mucous membrane. The mucosa is never thick and red and does not bleed whenever it is touched as it does in ulcerative colitis. The sigmoidoscope shows that the condition is strictly localized to the rectum, the mucous membrane immediately above the pelvi-rectal flexure being perfectly healthy. The X-rays also do not show any abnormality in the colon. In most cases the origin is quite obscure; but I have seen two cases in which it followed the administration of avertin, possibly owing to incomplete neutralization, and one case followed treatment of a carcinoma of the uterus with radium.

Carcinoma of the pelvic colon and rectum is often mistaken for ulcerative colitis, as the earliest symptoms may be diarrhoea with the passage of blood, mucus, and pus. But inspection of the stools generally suggests the correct diagnosis, as pus, blood, and mucus are passed without any faeces, or the latter are present in the form of small but solid fragments, whereas in ulcerative colitis there is always a little faecal matter which is like porridge in consistence and only tends to be solid when recovery is almost complete. Digital examination of the rectum, and proctoscopy or sigmoidoscopy, will reveal the diagnosis unless the higher part of the pelvic colon is involved; in that event the diagnosis should be suspected from the fact that the mucous membrane is devoid of ulcers and is only slightly inflamed as a result of irritation by the discharge from the growth. A characteristic feature is the discovery of blood and pus on the surface of a healthy or almost healthy mucous membrane, especially when more is seen coming down from a part of the colon beyond that reached by the instrument.

From carcinoma of pelvic colon and rectum

The most common source of bright red blood passed per anum apart from haemorrhoids is a polypus. If the haemorrhage is associated with diarrhoea, diagnosis of ulcerative colitis is likely to be made. Multiple polypi, and especially that form of polyposis which is generally familial and in which the whole colon is covered with innumerable polypi, may be associated with diarrhoea as well as the passage of much blood. The condition can be recognized on rectal examination and is confirmed by the sigmoidoscope and an opaque enema. The absence of a history of ulcerative colitis in the past and the absence of any co-existing ulceration excludes the form of polyposis which is secondary to ulcerative colitis.

From polypi

In one patient who was receiving treatment for ulcerative colitis I found on sigmoidoscopic examination innumerable submucous haemorrhages of varying sizes, the mucous membrane being otherwise quite healthy with no trace of ulceration. Blood exuded through the mucous membrane in many places so that the stools contained large quantities

From purpura

of it, but there was no mucus or pus. On subsequently examining the patient more carefully I found a few small petechiae under the skin. The blood-platelets were greatly reduced in number and the bleeding time much prolonged, so that the diagnosis was clearly thrombocytopenic purpura.

*From
multiple
telangiectases*

I have seen one case of rectal haemorrhage from multiple telangiectases, exactly analogous with the epistaxis which is a much more common event in this familial condition.

*From
enteritis*

I have seen several cases of enteritis diagnosed as ulcerative colitis on account of the passage of frequent watery stools, in spite of the absence of blood. Watery stools are caused by rapid passage through the small intestine, and as the small intestine is rarely involved in ulcerative colitis this generally indicates that the correct diagnosis is enteritis and not colitis—a diagnosis confirmed by an opaque meal which passes very rapidly through the small intestine, and by the sigmoidoscope which shows a normal but very wet mucous membrane.

(8)—Treatment

The most important factors in the successful treatment of ulcerative colitis are patience and perseverance on the part of both doctor and patient. Even in early cases several weeks of strict treatment are generally required; in chronic and late cases the patient may have to be in bed under continuous supervision for a year or more.

*General
treatment*

The patient should be kept completely at rest in bed so long as there is any pyrexia and so long as more than two or three stools are passed in the twenty-four hours. After that he may be allowed to get up for a warm bath and to lie on a couch during the day, but he must not take more exercise than is involved in walking from one room to another until recovery is complete.

Diet

As the small intestines are rarely involved in ulcerative colitis, it is quite unnecessary to make any restriction in diet beyond the avoidance of pips and skins of fruit and fibres of vegetables. Too limited a diet results in loss of weight and strength, and in addition it may not contain sufficient iron to compensate for the loss of blood in the stools, and microcytic anaemia then results. The anaemia and malnutrition, and particularly any deficiency in vitamins, aggravate the colitis and may lead to serious cutaneous and ocular complications, all of which respond rapidly to a change to a more liberal diet. Patients with ulcerative colitis often have quite a good appetite, and there is no reason for limiting their allowance of meat and other foods containing no indigestible residue. Fruit is best given in the form of strained juice and 'fool' and green vegetables as purées.

*Local
treatment*

Except in the most acute stages local treatment is often useful. The fluid should be run in through a soft catheter introduced only just beyond the anal sphincter. The quantity injected depends upon the extent of the disease as shown by X-ray examination. If the whole colon is involved a pint is needed; when introduced slowly at a pressure

not exceeding eighteen inches of water, it reaches the caecum without difficulty and is almost as effective as if given through an appendicular stoma. If the distal half only is involved, half or three-quarters of a pint are sufficient, and the patient should remain in a semi-sitting position so that the fluid cannot run into the more proximal part of the colon. The most useful solution is tannic acid, the strength of which is gradually increased from $\frac{1}{2}$ to 2 grains to the ounce; it should be retained, if possible, for half an hour.

The most satisfactory method of giving local treatment in cases of haemorrhagic proctitis and of ulcerative colitis in which only the more distal parts of the colon are involved is by injecting an emulsion of dermatol (bismuth subgallate) in an unirritating vegetable mucilage made from coreine (1 drachm to 4 ounces of water), which is neither affected by bacteria nor absorbed from the intestines. The emulsion, which is made up with 1 to 2 grains of dermatol to the ounce, is injected into the rectum in the evening and retained during the night. Any tendency to nocturnal diarrhoea can be controlled by adding 5 to 15 minims of tincture of opium to the mucilage, which is then generally retained without difficulty; after a time the dose of opium can be reduced and finally none may be required. This treatment has the great advantage of keeping the active therapeutic agent in contact with the mucous membrane for six or more hours instead of for a maximum of half an hour. It should be continued until the proctoscope shows that the last trace of inflammation has disappeared. For proctitis 4 ounces are required; when the pelvic colon is involved 6 or 8 ounces should be injected. Some patients are able to retain 10 or 12 ounces; this quantity is often sufficient to spread through the whole colon, so that the treatment can be tried as a substitute for injections of tannic acid solution in all cases of ulcerative colitis. Occasionally water is absorbed and difficulty is experienced in evacuating the emulsion in the morning; in such cases 1 or 2 ounces of paraffin should be incorporated in the emulsion.

When the diarrhoea is severe the patient is likely to become exhausted by want of sleep. A dose of codeine sufficient to keep the bowels from acting more than once during the night should be given at 10 p.m. In most cases the muscular coat of the colon is extremely irritable, and healing is retarded by its continuous activity. Tincture of belladonna should therefore be given every four hours, the dose being gradually increased from 5 minims to the maximum the patient can take without his mouth becoming uncomfortably dry. *Drugs*

Pain is not common in ulcerative colitis. Colicky pains, may, however, occur owing to distension with gas, especially shortly before the bowels act. They can always be relieved by a tablespoonful of charcoal given two or three times a day. *Charcoal*

Most patients with ulcerative colitis are more or less anaemic; 30 grains of iron and ammonium citrate should be given three times a day till the haemoglobin is at least 80 per cent. If the haemoglobin *Iron and transfusion*

percentage is less than 70, transfusion not only improves the patient's general condition, but often greatly hastens the healing of the ulcers.

Antiserum

Believing that the majority of cases of ulcerative colitis are the result of infection with a dysenteric organism, I have used multivalent anti-dysenteric serum in the treatment for the last fifteen years. After preliminary desensitization 20, 40, 60, 80, and 100 c.c. of serum are injected intravenously on consecutive days; sometimes a few additional doses of 100 c.c. are given. The treatment can only be undertaken safely in a hospital or nursing home where the patient is under continuous supervision, owing to the possibility of delayed anaphylaxis. If the patient is treated at home, 10 c.c. of serum should be injected intramuscularly daily for about ten days; good results are sometimes obtained, though less frequently than with intravenous injections. The great disadvantage of treatment with serum is the possibility of a dangerous anaphylactic reaction, which may occur during the injection of serum but may occasionally be delayed several hours. Prompt treatment with adrenaline, 1 minim of which should be injected every half minute after an initial injection of 3 minims until complete recovery takes place, is almost always effective.

Rapid recovery is most likely to follow serum treatment in the early stages, but it is occasionally very striking even in long-standing cases. More frequently the serum produces a certain degree of improvement, with the result that other treatment leads to recovery more rapidly than it otherwise would have done. In a small number of cases, especially very chronic ones, the serum has no effect. Though the improvement which follows serum treatment is probably in part due to protein shock, especially in cases in which there is much general reaction, yet in many cases it appears to be in part or entirely specific. Thus in one of my cases it was very effective, although no improvement had followed a series of injections of the same quantities of ordinary horse serum.

*Value of
vaccination*

I have never seen the slightest benefit follow any form of vaccination, and in some cases the local condition has been definitely aggravated. Several American physicians have told me that they have been quite unable to confirm Bargen's enthusiastic reports about treatment with the vaccine or serum (so-called 'ulcerative colitis serum') produced from his diplostreptococcus (see p. 297).

The danger of recurrence is much reduced if treatment is continued until the sigmoidoscope shows no trace of inflammation, even if symptoms have already disappeared for some weeks.

*Treatment of
associated
conditions*

Associated conditions, such as oral and pharyngeal infections, and anal complications, must be treated, as a relapse may follow an acute sore throat or the development of a peri-anal abscess or a fistula in ano. The patient should keep permanently on a roughage-free diet and take sufficient paraffin to keep his stools soft.

*Operative
treatment*

As the whole of the colon can be satisfactorily washed out with a pint and a half of fluid introduced per anum, and as in many cases

only the distal half is involved, appendicostomy or caecostomy is rarely indicated. A short-circuiting operation has been performed with success in three of my patients for fibrous stricture. When, in very chronic cases, a large part of the colon has become disorganized, with the formation of fibrous strictures and multiple polypi, all potentially malignant, the ideal operation is, I believe, a temporary ileostomy followed by colectomy. The end of the ileum is cut across; the proximal end is brought to the surface in order to divert the faeces from the colon, and the distal end is brought to the surface so that the colon can be washed daily with normal saline solution introduced by a tube passing through the ileo-caecal sphincter. After several weeks, when all active inflammation has disappeared from the colon, colectomy is performed; if endoscopy shows that there is no stricture within nine inches of the anus the lower part should be left so that the ileum can be anastomosed with it at a later stage. This operation has been performed on five of my patients with one death; in only one was it necessary to remove the rectum and to leave a permanent ileostomy. Any polypi in the rectum and the remaining part of the pelvic colon are destroyed by the diathermy cautery. The ultimate result in the four survivors was most satisfactory.

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(There is an excellent discussion on ulcerative colitis with radiological and pathological illustrations in the *Transactions of the 1st International Congress of Gastro-Enterology*, published in Brussels in 1935.)

COLLAPSE

See SHOCK AND COLLAPSE

COLOBOMA

See BLINDNESS, Vol. II, p. 411; RETINA DISEASES;
 and UVEAL TRACT DISEASES

COLON, CARCINOMA OF

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Reference may also be made to the following titles:

CANCER	DIVERTICULOSIS AND
COLITIS	DIVERTICULITIS
	ENDOSCOPY

1.—AETIOLOGY

251.] The total incidence of cancer is the same in both sexes; but in women carcinoma of the breast and uterus accounts for a large proportion of the cases, and it follows that in them the incidence in other situations—e.g. the colon—must be relatively lower than in men. Carcinoma of the colon is most common between the ages of 40 and 65.

2.—MORBID ANATOMY

Carcinoma is almost equally frequent in the colon and rectum. The following table shows the relative incidence in different parts of the large bowel.

Percentage Incidence of Carcinoma in Different Parts of the Large Intestine

Caecum	-	-	-	15	25	Pelvi-rectal flexure	-	65
Ascending colon	-	-	-	10	25	Ampulla of rectum	-	30
Hepatic flexure	-	-	-	5	50	Anal canal	-	5
Transverse colon	-	-	-	5				
Splenic flexure	-	-	-	10				100
Descending colon	-	-	-	5				
Iliac and pelvic colon	-	-	-	50				
				100				

The high incidence of cancer in the pelvic colon and rectum compared with that in the more proximal parts is probably due to the fact that their contents are relatively more solid and consequently cause more



FIG. 39.—Papilloma of rectum, $\frac{1}{4}$ inch in diameter, becoming malignant
(*Guy's Hospital Reports*, 1932)

mechanical irritation. The caecum and ascending colon are affected relatively often, because they are more constantly filled than any other part of the bowel except the pelvic colon and are subjected to irritation by the products of bacterial activity, such activity being greater in them than in any other part of the alimentary tract.

Carcinoma of the colon is most frequently a result of malignant degeneration of simple adenomatous polypi. In early cases the adenomatous origin is often obvious, and in 75 per cent of 33 specimens of carcinoma of the rectum and pelvic colon removed by operation, one or more simple adenomas were found to be also present (Dukes). Occasionally a carcinoma develops in a patient from whom a polyp has been removed at an earlier date; thus in 24 out of 50 cases in which a polyp had been removed another tumour in the rectum or pelvic colon developed, and of these 11 were malignant (Lockhart-Mummery). Polyposis of the colon, especially the severe familial form, very frequently ends in carcinoma, and carcinoma may also develop as a complication of the polyposis which is a common sequel of very chronic ulcerative colitis. In the colon two or more carcinomas develop, either simultaneously or in sequence, much more frequently than in any other organ, presumably owing to their origin in multiple adenomas.

*Association
with
adenomatous
polypi*

3.—CLINICAL PICTURE

The possibility of carcinoma of the colon should be considered whenever an individual over the age of 35 notices a change in the customary activity of his bowels. A man who has never taken an aperient in his life finds it necessary to do so with increasing frequency, or the dose which has been unaltered for years is now found insufficient. In other cases constipation may alternate with diarrhoea, or a tendency to looseness may occur instead of constipation. In carcinoma of the rectum and pelvic colon mucus, blood, and pus, separately and mixed together, are passed alone or with the faeces, which form small solid scybala, often irregular in shape, but without any special tendency to be tape-like. In addition to solid faeces small quantities of soft faeces may be passed and the mucus is often stained brown. In carcinoma of the more proximal parts of the colon there is generally nothing characteristic about the faeces, any mucus, blood, or pus being intimately mixed with it and not recognizable by the naked eye unless in great excess. The stools should be examined for occult blood which is invariably present; not only do the stools give a positive guaiac reaction, but it is generally possible to recognize the presence of acid haematin with the spectroscope—in contrast with the haematoporphyrin which is frequently present when the blood comes from the stomach or duodenum.

*Character
of faeces*

A vague discomfort in the lower part of the abdomen, which may be most marked on either side, though more frequently on the left, may be the first symptom or may accompany a change in bowel activity. After a time attacks of colic may occur, which are generally constant in position. The pain occasionally disappears suddenly with a gurgle. Localized discomfort or pain is common in carcinoma of the caecum and ascending colon, but comparatively rare when the more distal parts are involved.

Pain

Anaemia

In some cases loss of energy and slight dyspnoea due to anaemia may be the first indication that the patient is ill, further investigations revealing a growth of the colon, which has not yet given rise to any abdominal symptoms. The anaemia is generally a result of loss of blood by continuous oozing from an ulcerated growth. Occasionally

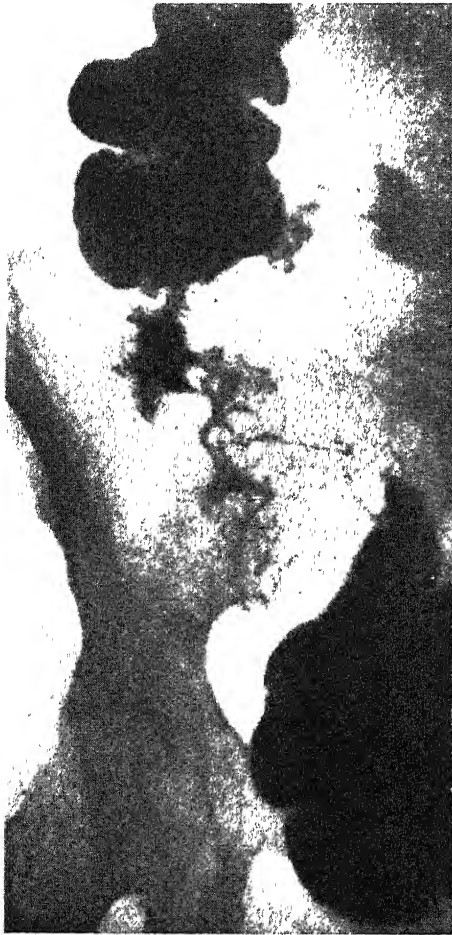


FIG. 40.—Carcinoma of caecum obstructing the ileo-caecal sphincter; radiogram 6 hours after opaque meal

a severe haemorrhage may occur, the blood being bright red or, if it comes from the caecum, dark, though never black as in the melaena of a duodenal ulcer. I have known a haemorrhage of this kind from a growth of the ascending colon precede all other symptoms. Carcinoma of the colon, especially of the proximal half, occasionally gives rise to severe anaemia as a result of toxæmia independent of haemorrhage. It is, however, important to remember that a large growth may develop and finally cause obstruction in the complete absence of anaemia.

In the early stages there is rarely any anorexia or loss of weight and, unless the patient has become anaemic, he often feels remarkably well.

A carcinoma of the colon is at first only likely to be palpable on abdominal examination in unusually thin patients. A tumour is

Palpation

most easily felt when it has a bony background, as with carcinoma of the caecum and the comparatively rare carcinoma of the iliac colon. A growth of the splenic flexure generally remains hidden under the left costal margin even when of considerable size. Digital examination will reveal a growth in the ampulla of the rectum, but the common carcinoma of the pelvi-rectal flexure is generally beyond the reach of the finger as well as too deep in the pelvis to be felt from the abdomen.

It may, however, be palpable on bimanual examination, especially in women. Growths of the pelvic colon are occasionally palpable in Douglas's pouch through the anterior rectal wall. Tumours of the transverse and pelvic colon are freely movable; a moderate degree of mobility is present when the caecum is involved, but growths of the ascending, descending, and iliac colon are more or less fixed owing to the absence of a mesentery. Growths of the colon are hard and free from tenderness unless complicated by the presence of secondary



FIG. 41.—Carcinoma of pelvic colon; opaque enema

inflammation, when the tumour may appear to be considerably larger than it really is. Occasionally its size is exaggerated by the impaction of solid faeces above it, the removal of which by an enema may even lead to the complete disappearance of a palpable tumour when the carcinoma is of the constricting annular form.

Both an opaque meal and an opaque enema should be given, as either of them may provide evidence of a growth when the other does not reveal any abnormality. The meal is especially valuable in carcinoma of the caecum (see Fig. 40) and ascending colon in which the faeces are soft, the enema in the more distal portions of the colon (see Figs. 41 and 42). Arrest of the onward progress of an opaque meal has nothing characteristic about it unless a filling defect is visible at the point of delay, as considerable delay may occur in simple constipation. A constant filling defect in the outline of the colon is patho-

*Radiographic
examination*

gnomonic. Palpation of the colon when visualized with the X-rays makes it possible to feel a tumour which had hitherto escaped observation. The further passage of an opaque enema may be delayed by a growth long before obstructive symptoms occur, owing to the tendency for the distension to call forth a local spasm at the seat of the disease,

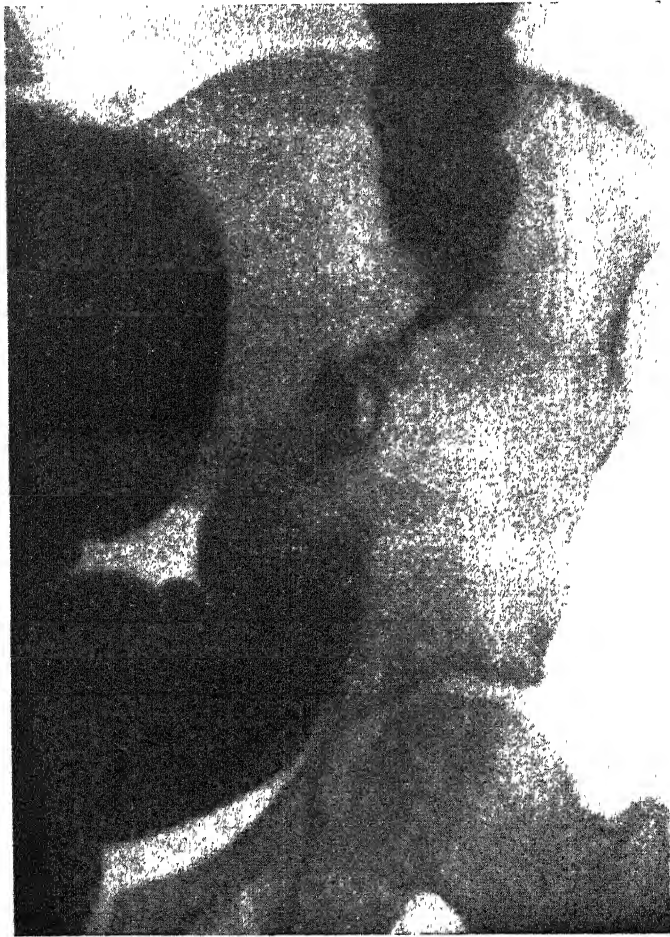


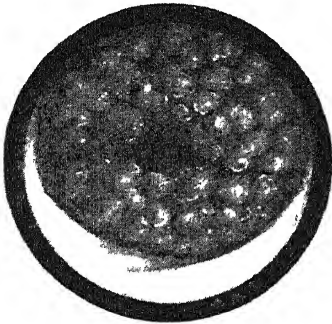
FIG. 42.—Carcinoma of iliac colon; opaque enema

but the nature of the obstruction can only be recognized with certainty if a filling defect can be seen in the radiogram. The opaque enema should be specially diluted if the pelvic colon is involved, as otherwise a filling defect may be hidden by the shadow of the bowel below the obstruction when it becomes distended by the enema. At least three radiograms should be taken after an opaque enema: (1) when all the fluid has been introduced, (2) after the greater part has been evacuated, and (3) after the introduction of some air before the whole of the enema has been expelled. The third radiogram is especially likely to show up

a malignant polyp which may not be visible in the first two radiograms.

Whenever the symptoms point to the possible presence of a growth of the pelvic colon or rectum an examination should be made with a short proctoscope and then, if nothing abnormal is found, with a sigmoidoscope (see Fig. 43). This should be done even if a tumour has already been discovered by digital examination, as the exact size and localization of a growth of the rectum can only be ascertained in this way. In the pelvic colon and at the pelvi-rectal flexure it is often possible to see no more than the lower end of a growth, as a stricture is likely to prevent the further passage of the instrument. If any doubt is felt about the nature of a tumour a fragment for microscopical examination should be removed through the instrument. A negative report is, however, not always

*Proctoscopic
and
sigmoido-
scopic
examinations*



(a)



(b)

FIG. 43.—(a) Proctoscopic view of carcinoma of pelvi-rectal flexure, $4\frac{1}{2}$ inches from anus, in woman of 63. Intermittent rectal haemorrhage for 6 years and daily haemorrhage for 18 months. No constipation. Abdomino-perineal excision. (b) Same growth after removal

reliable, as a stricture may prevent access to any but healthy mucous membrane. If the instrument is passed its full length and a growth has not been found, but blood with or without mucus and pus is seen to be coming from a yet higher part of the colon, although the accessible part of the mucous membrane shows no sign of ulcerative colitis, a growth is almost certainly present.

Complications

Localized peritonitis may occur with deeply ulcerated growths; in such cases a small abscess may form. The temperature is raised and

Peritonitis

there is a polymorphonuclear leucocytosis. Occasionally the resulting general symptoms of sepsis occur without any signs pointing to the seat of the disease. Perforation of an ulcerated growth or of a local abscess in connexion with a growth into the general peritoneal cavity with the development of general peritonitis is an extremely rare event.

*Gastro-colic
fistula*

A carcinoma of the transverse colon sometimes becomes adherent to the stomach and a gastro-colic fistula may develop. In patients who have not had a gastro-jejunostomy which could lead to an anastomotic ulcer perforating into the colon, a gastro-colic fistula is always malignant and much more often due to a primary growth of the colon than to one of the stomach. Foul eructations, faeculent vomiting, and severe but intermittent diarrhoea are the common symptoms, but any one of these may be present alone.

*Vesico-colic
fistula*

A carcinoma of the pelvic colon may become adherent to the bladder and a vesico-colic fistula develop, but this rare condition is more frequently a sequel of diverticulitis than of carcinoma. Irritation of the bladder caused by adhesions to the growth generally precede the passage of gas and faeculent material *per urethram* which indicates the presence of a fistula.

4.—PROGNOSIS

Invasion of the surrounding tissues and secondary deposits in lymphatic glands, the liver, and elsewhere occur more slowly and later in carcinoma of the colon than of most other organs. The prospects of a cure after operation when an early diagnosis is made are therefore exceptionally favourable.

5.—DIAGNOSIS

If the possibility of carcinoma is borne in mind whenever an individual over the age of 35 complains for the first time of irregularity of his bowels, abdominal discomfort, or symptoms of anaemia, and a thorough investigation is carried out, carcinoma of the colon should be recognized long before the development of obstruction. In most cases a diagnosis can be made with a fair degree of certainty with the aid of X-rays, especially if the stools constantly contain obvious or occult blood, even if no tumour is palpable from the abdomen or rectum or visible with the sigmoidoscope.

*Diagnosis
from
haemorrhoids*

A diagnosis of haemorrhoids should never be made on account of bleeding unless a local examination shows that haemorrhoids are actually present. Even then a digital examination should be made to exclude a growth of the rectum, and if mucus and pus accompany the blood a sigmoidoscopic examination should be made to exclude a growth of the pelvi-rectal flexure and lower half of the pelvic colon.

*From
ulcerative
colitis*

The presence of blood, pus, and mucus with diarrhoea naturally suggests ulcerative colitis, but in patients over 35 the possibility of carcinoma of the pelvic colon can only be excluded by endoscopy; in carcinoma small fragments of solid faeces are often passed, but many

of the stools do not contain any faeculent material: this is unusual in ulcerative colitis, in which the faeces are generally unformed and always soft.

A tumour in the course of the colon is generally a carcinoma. *From diverticulitis* except in the left iliac fossa, where it is more commonly caused by diverticulitis. In diverticulitis blood and pus are very rarely visible in the stools, which generally contain no occult blood. The diagnosis can always be settled by means of the X-rays. Though carcinoma may be associated with diverticulitis the latter does not predispose to the development of carcinoma.

Carcinoma of the caecum is in rare cases simulated by hyperplastic tuberculosis or Crohn's disease (see p. 503), a very chronic appendicular abscess, and actinomycosis. *From other conditions*

6.—TREATMENT

Polypi in the rectum or pelvic colon should be removed or destroyed by the diathermy cautery as soon as they are diagnosed, not only on account of the symptoms they are producing, but also because they may at a later date undergo malignant degeneration. Patients from whom one or more polypi have been removed should be examined by the sigmoidoscope at intervals of four months for at least ten years, so that any newly formed polypi may be promptly removed. If this is done, the development of carcinoma can be prevented, as there will be no time for a polyp to undergo malignant degeneration. *Prophylaxis*

Treatment of carcinoma of the colon is surgical. No form of radiotherapy is of any use, except for inoperable growths of the rectum, in which the distress caused by pain and irritating discharge can often be much reduced by treatment with radium. Before an operation an attempt should be made to raise the haemoglobin percentage of an anaemic patient to 80 per cent, by large doses of iron and transfusions; paraffin but no other aperient should be given by mouth, and the colon should be kept as empty as possible by enemas until the operation is performed. In most cases a two- or even three-stage operation is far safer than a primary colectomy. *Surgery*

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COLON, MELANOSIS OF

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Reference may also be made to the following titles:

COLON, CARCINOMA OF	DIARRHOEA
CONSTIPATION	ENDOSCOPY

1.—DEFINITION

252.] Melanosis coli is a condition in which the mucous membrane of the colon becomes pigmented as a result of the deposition of melanin, which is formed from substances absorbed from faeces undergoing excessive putrefaction.

Historical

The earliest reference to melanosis coli appears in Cruveilhier's *Anatomie Pathologique* (1829–35). 'M. Andral', he says, 'has found, in an individual affected with chronic diarrhoea, the inner surface of the large intestine as black as chinese ink, from the ileocaecal valve right down to the rectum. This colour resided in the internal membrane.' Virchow described the condition in 1847, and in 1858 secured a specimen, now in the museum of the Pathological Institute at Berlin, labelled in his own handwriting 'melanosis coli'. The first case reported in

England (Theodore Williams, 1867) is of particular interest in that very dark pigmentation was discovered in the mucous membrane of a rectal prolapse which developed a few days before death. At autopsy 'the internal surface of the large intestine was remarkably black, mottled in parts with patches of a lighter hue, the colour commencing at the ileo-caecal valve, and contrasting strongly with the light colour of the small intestine'. The earliest detailed account of the morbid anatomy of melanosis coli was given by Pick in 1911. He noted the absence of pigment from the epithelial cells and its restriction to large mononuclear cells in the mucosa. Henschen and Bergstrand (1913) showed that, while gross examples are comparatively rare, microscopical pigmentation of the colon is common. They also demonstrated for the first time that the pigment could be transported to the mesocolic lymph glands.

2.-AETIOLOGY

The fullest description of the pathology of melanosis coli was published in 1931 by Stewart and Hickman who, in a series of 600 closely scrutinized autopsies, found 67 cases (11.2 per cent) of melanosis *Incidence* visible to the naked-eye. These they graded into five categories from slight (just recognizable browning) to + + + + (very deep brown to black), with the following result: slight, 26; +, 18; ++, 15; + + +, 5; and + + + +, 3; total 67.

The more intense grades of pigmentation are chiefly seen in later life, but the earlier decades, from 30 to 59, are not exempt. With the sigmoidoscope I have seen an extreme degree of melanosis involving the rectum and pelvic colon in a young man of 27. The sexes are about equally affected.

3.-PATHOLOGY

Virchow (1847) believed that the pigment was haematogenous, but it does not give the Prussian blue reaction. In the cases described by Williams (1867) and Rolleston (1892) mercury, and in Pitt's case (1891) lead, was present in the mucosa. Heavy metals, however, have not been found in any more recent cases. *Nature of the pigment*

All investigators now agree that the pigment is a melanin, similar to, or identical with, that of the skin and hair (Pick; Lubarsch). Pick and Brahn (1930) found that solutions of extracted and purified melanin from four different cases of melanosis coli gave as definite vascular contraction in the Trendelenburg frog-reaction as the melanin from the urine in a case of melanomatosis. Pick believed that aromatic protein degradation products were absorbed from the colon and converted into melanin within the connective-tissue cells by a tyrosinase-like ferment.

4.—MORBID ANATOMY AND HISTOLOGY

*Distribution
of pigment*

The pigmentation varies from pale grey or buff through dark grey or brown to inky black. It is deepest in the caecum and ascending colon and becomes gradually less on passing down the gut; in very advanced cases dark brown or black pigmentation may extend to the lower extremity of the rectum, but the anal canal is always completely free. In the slighter grades only the caecum and ascending colon may be affected. The pigmentation is sharply delimited above by the ileo-caecal valve, the contrast in advanced cases between the inky black caecum and the pale ileum being most remarkable. When the rectum is involved the contrast, seen with a proctoscope, between the black ampulla and the pale anal canal is equally striking.

'Melanosis of the appendix may accompany the intestinal lesion or may occur apart from it as a result of local appendicular stasis with putrefaction. . . . In the colon the pigmentation is not uniform, even in a given portion of gut. In advanced cases the brown or black field is broken up into tiny areas of almost uniform size and shape by a network of fine unpigmented lines, corresponding to the ramifications of the mucosal blood-vessels. In slighter grades, the pigmented spots are smaller as well as lighter in tint, a greyish or brownish stippling on a pinkish background. The solitary follicles of the intestine, being devoid of pigment, stand out as little white or yellow points. . . . In the comparatively infrequent instances of metastasis of pigment to the mesocolic lymph glands the latter may appear brownish in tint.

Histology

'In the vast majority of cases the pigment is confined to the stroma of the mucous membrane, where it lies within the cytoplasm of large mononuclear cells, whose precise nature is still unsettled. The distribution within the mucosa varies. In the slightest grades, and especially where the melanosis is only discovered on microscopic examination, the pigment is usually limited to the tips of the mucosal villi. In the grosser forms, the melanin-containing cells are either congregated in the depths of the mucous membrane close to the muscularis mucosae or scattered more or less uniformly throughout its thickness. We suggest as an explanation of this varied distribution, that the formation of melanin takes place mainly in the surface zone, with a later downward migration of the melanin-containing cells. So long as the absorption of the melanogen continues, so long will there be melanin in the surface layers, with a gradually increasing accumulation in the depths.

*Character of
pigment*

'The character of the pigment also varies. In the slighter grades there is a finely granular deposition of yellowish-brown pigment in the cytoplasm of the large mononuclear cells. The granules may be so fine as to be detectable only with the oil immersion lens; with lower powers the cell may appear to be possessed merely of homogeneous yellowish or brownish cytoplasm. As the process becomes more intense the granules increase in size, and assume in consequence a deeper colour. The pigment-containing cells may be either irregularly polygonal in outline, so that when they occur in clumps they fit so closely together as to render it impossible to distinguish the outline of individual cells; or they are rounded or ovoid in shape, discrete, and quite detached from one another. In the latter the

pigment is always of a rich deep brown, and the cells are so completely filled that it is often impossible to distinguish separate granules or to make out the nucleus. Such cells are more frequent in the deeper layers of the mucosa and it is always this type which is met with outside the muscularis mucosae and in the mesocolic lymph glands.

'While the vast bulk of the pigment is everywhere intracellular, scattered free granules may often be detected here and there, probably due to the disintegration of pigment-containing cells. The epithelium of the mucosa, whether superficial or glandular, is invariably pigment-free, and the solitary follicles of lymphoid tissue usually so.' (Stewart and Hickman.)

5.—RELATION BETWEEN MELANOSIS COLI AND CARCINOMA COLI

Stewart and Hickman pointed out the frequent association of melanosis with carcinoma of the colon. This is well seen in the following table in which, in order to eliminate the age factor, they give the comparative incidence of melanosis in persons over forty with and without carcinoma of the colon.

CLASSIFICATION OF CASES		NUMBER	PERCENTAGE
		WITH MELANOSIS	WITH MELANOSIS
Total autopsies over 40 years of age	327	58	17·7
(1) Cancer of colon cases	— 43	21	48·8
(2) Non-cancer of colon cases	284	37	13·0
Relative frequency in groups 1 and 2, 4 : 1			

In a clinical series of 100 cases of carcinoma of the colon they found a similar incidence, 55 per cent, with an additional 13 per cent in which melanin was discovered microscopically. There was a remarkable difference in the depth of pigmentation above and below the growth. 'Excluding the 8 cases of cancer of the caecum in which there was melanosis of the ascending colon without either naked-eye or microscopic involvement of the ileum, there was only one case in which the pigmentation was more marked below the growth. Of the remaining 59, in 9 there was no appreciable difference in the two sites, in 33 the melanosis was more marked above the growth, and in 17 it was present in this situation only.'

The stasis of semi-fluid faeces in the part of the colon proximal to a carcinomatous obstruction must lead to excessive putrefaction and the production of excess of the substances which form melanin on absorption by the mucous membrane.

6.—INFLUENCE OF CONSTIPATION, PURGATIVES AND ARTIFICIAL DIARRHOEA

Henschen and Bergstrand were the first to emphasize the importance of *Constipation* as an aetiological factor. They believed that excessive

putrefaction occurred in the colon of constipated individuals and that melanosis was produced in the mucous membrane by the transformation of the products of putrefaction. Stewart and Hickman, like all recent writers, accepted this theory that the condition is secondary to constipation, although it was not possible to obtain an adequate history in any of their autopsy series. 'Obstinate constipation' was present in all of the 26 cases observed by Bockus, Willard, and Bank. It had generally been present for many years and was often the main reason why the patient had sought medical advice. All the patients were dependent upon laxatives, their bowels remaining unopened unless they took sufficient to produce a soft evacuation.

*Anthracene
laxatives*

In 35 of the cases in the series recorded by Bockus, Willard, and Bank the nature of the laxatives was known; in 27 it was cascara alone or in combination, in 7 aloes, and in 1 senna. As all their patients had habitually used one of the anthracene group of purgatives, they concluded that the melanosis was not a direct result of constipation, but that 'the anthracene laxatives either contain a pigment or elaborate one within the colon which is phagocytosed by the deep mucosal cells, causing melanosis'.

*Artificial
diarrhoea*

I have on many occasions pointed out that the symptoms of intestinal auto-intoxication which are commonly ascribed to constipation are really the result of the artificial chronic diarrhoea which results from the habitual use of aperients taken because of genuine constipation or, more frequently, because of the groundless fear that constipation might otherwise occur. I have no doubt that the assumption that melanosis coli is a result of constipation is due to a similar error, and that it is really the result of the artificial diarrhoea induced by habitual purgation. I agree with Bockus, Willard, and Bank that the important factor is the aperient drugs and not the constipation, but am convinced that the cause of the melanosis is the diarrhoea brought about by these drugs and not, as they believe, the drugs themselves. The early case described by Williams (1867) supports the view that neither constipation *per se* nor an anthracene laxative was responsible; indeed, far from being constipated the patient, a woman of 74, must have suffered from chronic diarrhoea, as she 'had for the last 43 years of her life been in the habit of taking a grain of calomel every night, except on some twenty occasions, when she substituted either blue pill or grey powder. In addition she took an extra dose of calomel varying from half a grain to one grain twice a week.' It is interesting to note that in the earliest recorded case, that of Andral mentioned by Cruveilhier (1829), the patient suffered from chronic diarrhoea. Moreover, Bockus, Willard, and Bank note that the stools of 27 out of 30 patients with melanosis which were examined were 'mushy or fluid', the result of purgation, although they were said to be suffering from 'obstinate constipation'.

In the only case in which I examined the patient whilst she was taking her usual aperient, I found almost the entire surface of the mucous membrane of the pelvic colon and rectum down to the entrance into

the anal canal covered with soft, unformed faeces, although her bowels had been opened as usual after breakfast a couple of hours before. When the faeces were wiped away the typical appearance of severe melanosis was seen; the whole of the rectum was involved, but the anal canal was spared. That is to say, melanosis was present in the part of the mucous membrane which was constantly covered with soft faeces, from which decomposing products would be continuously absorbed; but it was entirely absent from the anal canal, in which there were no faeces. This is in marked contrast with the state of affairs in untreated constipation. In 'colonic constipation', in which the stasis is in the proximal half of the colon, the rectum is completely empty. In the more common rectal constipation (dyschezia), it contains hard scybala, which are in contact with the mucous membrane over a very small part of their surface area; most of the mucous membrane is not in contact with faeces at all. It is obvious that little or no putrefaction can occur in hard, dry faeces and that little or no absorption of toxins can take place from the surface in contact with the mucous membrane. A further contrast is the strong faecal odour of the unformed faeces of a patient taking an aperient with the almost odourless scybala of severe constipation, whether colonic or rectal.

Whenever possible, patients whom I intend to examine with a proctoscope and sigmoidoscope are given no aperients or enemas during the preceding forty-eight hours, though they are instructed to try to open their bowels naturally each morning and again just before the examination. As a result of this in every case of melanosis coli which I have observed, with the exception already mentioned (see p. 330), the surface of the mucous membrane has been clean and dry. In some cases dry scybala were lying free in the rectum, and only a very small fraction of the total area of the rectal mucous membrane was in contact with them. More frequently the rectum was completely empty, though scybala were generally present in the pelvic colon; in spite of this the rectal mucous membrane was pigmented up to the entrance of the anal canal.

7.—CLINICAL PICTURE

Apart from Williams's case mentioned on p. 327 the earliest clinical description of the condition was made by Strauss, who in 1911, at the meeting in Berlin at which Pick recorded his pathological investigations, described his observation of a pigmented colon with the sigmoidoscope. It is mentioned as a rare occurrence by most writers on sigmoidoscopy, but the only detailed clinical investigation is that made by Bockus, Willard, and Bank (1933). They found melanosis coli in the course of 26 of a series of 553 sigmoidoscopies, i.e. in 4.7 per cent. Though I have not any accurate statistics on the subject, their figures agree with my own estimate of its incidence from endoscopic examinations.

*Endoscopic
observations*

8.—DISAPPEARANCE OF PIGMENTATION

Bockus, Willard, and Bank treated the constipation of their patients with melanosis coli by diet, paraffin, and agar. The continued use of laxatives was prohibited, but in some cases a little magnesia was allowed at first. In 15 of 18 cases in which the colon was re-examined at intervals varying between four and twelve months after the use of aperients had been discontinued the melanosis was found to have disappeared. In 2 of the remaining 3, examined after intervals of only three and six weeks respectively, the pigmentation was already less intense. In only one, examined after four months, was there no change. From these data Bockus, Willard, and Bank concluded that the pigmentation was caused by the anthracene aperients used by their patients, but the disappearance of pigmentation can equally be explained as a result of the substitution of normal formed stools for the loose stools produced when the aperients were taken. I have no doubt that this was the cause of the disappearance of pigmentation in the following case:

A lady, aged 39, was admitted to New Lodge Clinic on March 13th, 1936, on account of abdominal pain and constipation. For sixteen years she had been taking from 20 to 40 senna pods and more recently 16 taxol pills every night. (Taxol is said to be composed of extract of intestinal mucous membrane and extract of bile, but presumably owes its aperient properties to some added purgative.) She had an extreme melanosis in the whole of the pelvic colon accessible to the sigmoidoscope and in the rectum as far as its junction with the anal canal, where it ceased abruptly. Her pain proved to be due to the excessive quantity of aperients she was taking. She was not really constipated, as her bowels were found to act regularly with nothing more than a tablespoonful of paraffin and a teaspoonful of coreine (an unirritating vegetable mucilage) morning and evening. On this regime she passed a single formed stool every morning instead of several bulky liquid stools as she had done during all the years she was needlessly drugging herself. On September 9th, six months after the first examination, a sigmoidoscopic examination showed that the melanosis had disappeared completely, no trace of the pigmentation present at the first examination being visible in the mucous membrane of the pelvic colon or rectum.

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COLON, TUBERCULOSIS OF

See INTESTINES, TUBERCULOSIS OF

COLOUR VISION

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1.—VOCATIONAL IMPORTANCE OF COLOUR VISION

253.] The majority of occupations make comparatively unexact demands upon unaided colour vision. Decisions of vital moment do not depend solely on accurate differentiation of colour because numerous accessory aids, such as size, shape, relative brightness, position, texture, and previous experience, are always available and these serve effectively to mask and neutralize the colour-defective worker's potential disability. Should a qualifying test be necessary, it is not difficult to devise a practical task which will be a test of colour perception under the working conditions which obtain in the particular occupation concerned.

In some branches of the defence and transport services, however, the position is entirely different. Coloured signals—stationary or moving at speed—must be differentiated almost instantly at great

distances (2 to 3 miles) under varying and often unfavourable weather conditions without any assistance whatsoever from adventitious aids. On one man's capacity consistently to maintain this high standard of unaided colour perception not merely efficiency but hundreds of lives may depend. Thorough examination is essential to meet the requirement of the official regulations. If the tests applied are inadequate, the conclusions drawn from them are likely to be seriously fallacious.

So numerous are the theories of colour vision, and so vast and controversial is the literature which has accumulated round them, that fundamental facts of practical importance, to explain which the theories were propounded, are apt to be obscured and the whole subject is regarded as being a forbidding tangle of speculation. Yet the essential facts which must never be forgotten in practical testing have been established by observation and experiment and are not dependent on theory.

In addition, the popular interpretation of the term 'colour-blindness' has led to much misapprehension. Few, if any, of the so-called 'colour blind' are blind to all colour. They are not blind in the popular sense of the word any more than a man who reads only 6, 12 is form-blind. But their colour perception differs, in some degree, from the colour vision of the average ('normal') person in that they are capable of differentiating a smaller number of hues. It is preferable to describe them as being *colour-defective* or *colour-different*. The unscientific use of the term 'colour-blindness' perpetuates the mistaken idea that any person who does not commit glaring errors in his interpretation of colour in everyday life with its multitude of compensatory aids possesses normal colour vision and is, therefore, fit to undertake any and every kind of work in which colour perception plays a part irrespective of the difficulties imposed by the working conditions of his employment.

*Definition
of terms*

The truth of the matter is that while the technical investigation of colour vision is rarely so complex as some of the literature suggests, it is never so simple as popular misinterpretation of the terminology implies.

2.—NORMAL COLOUR VISION (TRICHROMATISM)

A person with normal colour vision is able to differentiate six essentially different colours in the luminous spectrum—red, orange, yellow, green, blue, and violet. A few exceptional persons can differentiate a seventh colour—indigo—between the blue and the violet. When a person with normal sight is asked to match any given monochromatic spectral light, he does so by mixing suitable proportions of three primary colours—spectrum red, green, and blue or violet. Normal colour vision is therefore a function of three variables and is said to be trichromatic.

3.—CONGENITAL DEFECTS OF COLOUR VISION

Inheritance Congenitally defective colour vision is an inherited and permanent defect, manifested as a rule in the male but transmitted through the female line. It is ten times more common among males, of whom about 4·7 per cent are crudely defective, and about 20 per cent are *imperfect* (see HEREDITY AND CONSTITUTION).

(1)—Dichromatism

*Classification
of dichromats*

Any considerable batch of men will contain some who, in matching a monochromatic light, are satisfied with a mixture of only two primary colours, e.g. red and blue or red and violet. Their colour vision is thus a function of two variables and they are said to have dichromatic colour vision. Dichromats differ markedly in the colours which they confuse. Helmholtz classified them as red-blind, green-blind, or blue-blind. For these terms, von Kries substituted the names protanopes, deuteranopes, and tritanopes, which have the advantage of being purely descriptive and unwedded to any particular theory of colour vision. Deuteranopes outnumber protanopes in the proportion of about five to one. Tritanopes are rare and they are of very little practical importance because blue is not one of the colours used for distant signals.

The detection of dichromats is not usually difficult, but it calls for careful technique since they are often expert in making use of adventitious aids.

(2)—Monochromatism

The colour vision of the monochromats is a function of only one variable. They are very rare and describe the luminous spectrum as a grey band the several regions of which differ only in brightness. They are easily recognized because, in addition to extremely defective colour vision, they present nystagmus, photophobia, and grossly impaired form vision which is due to retinal causes and cannot, therefore, be corrected by means of lenses. In the absence of disease of the eye, dichromats and trichromats on the other hand possess form vision 6/6 or better when errors of refraction have been corrected.

(3)—Anomalous Trichromatism

This group of colour-defectives is of great importance in connexion with those occupations which call for a high standard of colour perception. To detect them all and to segregate those who, though abnormal, are safe, from those who are potentially dangerous, requires accurately designed apparatus, careful technique, and a constant recollection of certain of their characteristics.

Like the normal trichromats, they use a mixture of three primary colours to produce their matches, but the proportions of the component

colours used by them differ from the normal. They are described as protanomalous, deuteranomalous, or tritanomalous trichromats according as their deficiency is for red, for green, or for blue.

The following characteristics will be encountered time and again in varying degrees and combinations when testing their colour vision. *Characteristic features*

(1) The colour source must stimulate a relatively large area of retina if its colour is to be differentiated correctly. For instance, a coloured signal or navigation light which, in clear weather, is recognized by the normal trichromat when it is two to three miles away may have to approach very much closer before the anomalous trichromat is certain about its colour. *Distance*

(2) For differentiating colours, they rely on differences in brightness (luminosity) rather than on differences in hue. Through endeavouring thus to compensate for their defective colour vision, the anomalous trichromats acquire an enhanced capacity to appreciate minute differences and changes in brightness. This is the most generally utilized of the many adventitious aids by means of which colour-defectives contrive to conceal their abnormality. The attribute may be an advantage in some of the arts and crafts (metal work, textile work, and even painting). At sea, on the railways, and in the air, where coloured lights have to be recognized solely by virtue of their redness, greenness, or whiteness, interpretation by assessment of brightness may, if it is relied upon unduly, be a source of dangerous error. For example, only a single light may be visible. There is then no direct standard of comparison and a too-anomalous trichromat is forced to depend on his memorized scale of brightness values. Further, a light which is unobscured at one moment may, soon afterwards, have its brightness altered by mist, rain, or smoke. This change in brightness may be mistaken for a change in colour. *Reliance on relative brightness*

(3) Fatigue may cause their colour perception to deteriorate so that they become unreliable guessers after a short period of work. The safe trichromat differentiates colours accurately and consistently throughout any reasonable length of time. *Fatigue*

(4) By comparison with normal trichromats, their latent period is prolonged. Where the normal trichromat differentiates colour instantly, the anomalous trichromat hesitates while he musters to his assistance every available accessory aid. Delay is fraught with danger in the defence and transport services. To lay down precise limits for the maximum latent period which can be accepted is not easy, but, as a rule, men whose latent period exceeds 15 seconds should be regarded as being seriously defective. *Prolonged latent period*

(5) Contrast, simultaneous and successive, is exaggerated. Thus, a green light seen with, or immediately after, a blue-green, may be called 'red'. *Exaggerated contrast*

(6) They can differentiate coloured lights if the intensity is high enough, but they may fail with lights of lower intensity which are yet sufficiently distinctive to the normal-sighted person. *Effect of intensity*

Inconsistency (7) Their performance in technical tests is apt to vary widely from time to time. There is evidence that their inconsistency is due, not to variations in their colour vision *per se*, but to variations in their capacity to make use of accessory aids. It is possible to educate an anomalous trichromat so that he is no longer dangerously unreliable, but such cases are very exceptional indeed. Only after the most exhaustive examination should an examinee who has once failed be accepted as fit. In fact, the investigation will always demonstrate that his basic defect persists although his capacity to compensate for it has increased.

(4)—Shortening of the Spectrum

One other defect of importance in practice must be considered. Some persons are able to differentiate all six or seven colours in the luminous spectrum, but the red end or the violet end is shortened as compared with the normal. Obviously, shortening of the red end has serious possibilities in some occupations, since persons so affected are unable to recognize red at a safe distance. Shortening of the violet end is more of scientific than of practical interest because these colours are not used for signs or signals.

4.—TESTS OF COLOUR VISION

The kind of test employed depends upon the purpose of the investigation. If a precise diagnosis of the nature and degree of the defect is required, exact quantitative measurements must be made with spectroscopic apparatus using pure coloured light under carefully controlled laboratory conditions. For vocational selection, less sensitive qualitative tests suffice for all except a few difficult borderline cases which must be referred to experts for decision.

Many tests adapted for use in the consulting room have been devised. None is infallible, and none is fool-proof; but the risk of erroneous decisions is small if several recognized tests are accurately applied. Obviously, when public safety depends upon adequate colour perception, the decision in borderline cases must be given against the candidate and not against public safety.

In the tests (except Nagel's) about to be described, both eyes are tested together. If the examinee's form-vision is imperfect and the use of glasses is permitted in his occupation, he should be allowed to wear them during the test. It is assumed throughout that the examiner is a normal trichromat.

(1)—Pseudo-Isochromatic Card Tests

Pseudo-isochromatism is a fundamental phenomenon of defective colour vision. Colours unmistakably different to the normal-sighted

are confused by the colour-defective. This fact is used ingeniously in designing the card tests.

Coloured dots or patches are lithographed on cards in such a way that the component dots of a numeral or letter are mingled with dots of a confusion colour. The normal trichromat thus sees one outline, whereas the colour-defective either sees no outline at all or sees an entirely different outline. Some of the cards contain figures which stand out clearly for certain colour-defectives but are not distinguishable by the normal-sighted. Certain cards are designed to detect simulation and dissimulation while others help to distinguish between 'red-blindness' and 'green-blindness'. The card tests have the advantages of being simple, rapid, compact, and cheap. In them form-vision cannot come to the aid of defective colour vision and they call for little intelligence on the part of the examinee.

Ishihara's *Test for Colour-Blindness* and Boström's *Tabulae Pseudo-isochromaticae*, which are designed specifically to detect so-called red-blindness and green-blindness, incorporate all the merits of the card tests. Other reliable tests are those of Edridge-Green and of Stilling. These are more complex and extensive, as they include tests for 'blue-blindness' and 'yellow-blindness'.

Ishihara's test
Boström's test

The examination should begin by application of one, or preferably two, reliable card tests. The test is conducted in good daylight, but direct sunlight is not allowed to shine on the cards. In dull weather, or at night, 'daylight' lamps should be used, but it is absolutely essential that they should be of thoroughly reliable manufacture. The candidate is told to look straight at the cards from a distance of about 2 feet and, without undue hesitation, to write down the numerals as he sees them. He is warned that some of the cards do not contain any figure, and that, if he attempts to guess, he will certainly make mistakes. As some examinees have been coached in colour-vision tests the order in which the cards are shown should be varied, or cards from the Ishihara and Boström series be mixed. The booklet supplied with the cards should be used to interpret the results.

Technique

An examinee who makes any mistake in the card tests is not a normal trichromat, and is therefore unfit for any occupation for which the relevant official regulations stipulate strictly *normal* colour vision as a rigid and arbitrary requirement. Though abnormal, he is not necessarily dangerously defective and may be fit to enter for instance the Royal Navy where *safe* colour vision for his prospective duties is the official requirement (see Medical Research Council, Special Report Series, No. 185). On the other hand, a correct set of answers is not always conclusive evidence of safe colour vision. A lantern test may reveal a disqualifying defect such as shortening of the red end of the spectrum.

Interpretation of results

A lantern test (see below) should now be applied, the evidence derived from the card tests being borne in mind throughout. A specially thorough examination should be made of any candidate who made

a mistake in the card tests, who approached close to the cards, who attempted to look at them obliquely, who altered a figure after he had written it, or who hesitated for more than 15 seconds over a card.

(2)—Lantern Tests

These tests are well adapted to reproduce the conditions under which signal lights have to be differentiated on the railways, at sea, and in the air. The colour, size (distance), and luminosity of the lights can be altered at will.

Another feature is that the colours have to be named by the examinee. There has been much difference of opinion about the value of colour names in a technical test. Not only must a look-out say to himself 'That is a red light' or 'That is a green light' before he can take the action indicated by the signal, but he may be required to report the name of the colour to other persons who have to make decisions of critical importance although they are not in a position to see the light for themselves. Only those lanterns are reliable in which the apertures are accurately calibrated and in which the colours shown are representative of those encountered on duty.

*Martin
lantern
Edridge-
Green dual
lantern*

The *Martin lantern* and the *Edridge-Green dual lantern* meet these requirements. With them, coloured lights can be exhibited through apertures which, at a distance of 20 feet, represent the angular magnitude of a ship's navigation lights at 2,000 yards. Illuminated indicators, visible to the examiner only, enable him to make notes (Martin lantern) or to dictate to an assistant (Edridge-Green lantern) without compromising the test in any way. The fact that in the Martin lantern all the lights shown are, to the normal eye, of strictly equal luminosity simplifies the technique of testing. The Edridge-Green lantern depends on a great number of colours of unequal brightness to confuse the colour-defective examinee. In both lanterns neutral glasses are fitted which alter the luminosity of the lights and provide additional test colours.

The test should be carried out in a room from which daylight can be excluded. Preferably the room should be at least 20 feet long, but if only a smaller room is available, the lantern can be used in conjunction with a plane mirror at a distance of 10 feet. The latter method has the advantage that examiner and candidate see the lights reflected in the mirror. The apertures of the lantern should be at the level of the candidate's eyes. On no account should any light be allowed to shine on the front of the lantern. Dark adaptation is not essential at the outset. Under working conditions, look-outs are not dark-adapted when they begin duty. A candidate should not, however, be rejected unless he makes significant mistakes after 15 minutes' dark-adaptation. The candidate should be informed that he is required to name the colour of the lights from left to right but that, if he thinks that he knows the colour of a light, but is uncertain about the name, he may *describe* the colour. He should be warned against guessing and against

prolonged hesitation. A few lights should now be shown through a large aperture so that the examinee can learn exactly where to look. The 0.02 inch apertures should now be substituted and the test proper commenced by making a complete circuit of the colours. The colours should not be shown in a routine sequence and, occasionally, a pair should be omitted (the apertures being closed the while), or the direction of movement reversed.

If a candidate calls the white light 'red' or 'yellow' when it is first shown, it should be explained to him, once only, that the light is supposed to be 'white' or 'clear'; with this exception no comment should be made on any of the examinee's answers. A single unguarded comment or question may defeat the object of the test by supplying an adventitious aid or hint which is not available under working conditions in the candidate's employment. To remark 'I cannot hear you' is a useful non-committal way of asking him to repeat an answer.

The examination should always include the tests for shortening of the red end of the spectrum by making certain that he can differentiate the red lights (with and without neutral glasses) at a distance greater than half that at which they can be recognized by a normal trichromat (the examiner).

As a rule, two circuits of the colours are a sufficient test, but an examinee who has made a mistake in the card test should not be accepted without a more prolonged examination. Provided that he has had time to become dark-adapted, the test may be terminated as soon as he has made a disqualifying mistake. The significance of his mistakes is always more important than their number.

A candidate should be regarded as being unfit for such occupations as engine-driver, signalman, look-out at sea, or pilot of aircraft, if he makes any of the following mistakes: reports a red as 'green' or a green as 'red'; reports a red, a green, a white, or a yellow as 'no light' or as 'black'; reports a red or a blue-green as 'white', or vice versa; reports white or yellow as 'green'; persists in calling a white or a yellow 'red' after the difference between these colours has been demonstrated to him *once*. *Disqualifying mistakes*

In the absence of other and more significant mistakes, the following should not be regarded as disqualifying errors: reporting blue as 'green' or vice versa; reporting a yellow-green, or a light green, shown with, or immediately after, a blue-green or a blue, as 'white', or as 'yellow'; or reporting yellow as 'white' or vice versa. There should be hesitation in accepting a candidate who has made any mistake in the card tests, and in rejecting one who has performed them correctly. *Other mistakes*

(3)—Nagel's Anomaloscope

The use of Nagel's anomaloscope is a valuable additional test for doubtful cases. Through a telescope, the examinee views a circular field the lower half of which is illuminated through a prism adjusted to give only orange-yellow light from the region of the sodium line

of the spectrum. The upper half is illuminated through two prisms adjusted to provide a mixture of red and green. There are two screws on each of which a scale is engraved. One screw controls the mixture of red and green; the other controls the brightness of the sodium yellow. The test consists in matching the two halves of the field for colour and for brightness. The examiner assesses the match produced by the candidate by inspection and by reading the scales of the instrument.

5.—ACQUIRED DEFECTS OF COLOUR VISION

Significance of acquired defects

Acquired defects of colour vision are always due to the effects of injury, disease, or old age on the retina, the optic nerve, the brain, or the lens. Colour defects are often present before form-vision or the field for white is implicated, but usually they are not discovered until some impairment of form-vision, which cannot be corrected by glasses, has occurred. Changes in the colour fields are of much diagnostic value.

In practice these changes are detected by the methods of perimetry. Careful technique is essential and intelligent co-operation by the patient is invaluable.

Normal colour-fields

The normal field of vision for colour is less extensive than the field for white, but it is of similar outline. Under the ordinary conditions of clinical examination, the field for yellow and blue is, approximately, 10° smaller than the field for white, and the field for red and green is about 10° smaller than the field for yellow and blue. As a rule, the field is smaller for green than for red and that for violet is the smallest of them all. Given large test objects of great brightness and colour saturation, colours, with the possible exception of green, can be differentiated up to the extreme periphery of the field.

Optic neuritis and optic atrophy

In optic neuritis and optic atrophy the colour field shows peripheral contraction and frequently the outline is irregular. Scotomas occur earliest for green, then for red, later for blue, and last for white.

Retrobulbar neuritis

A central scotoma occurs in cases of retrobulbar neuritis, such as may be caused by syphilis, poisoning by arsenic, lead, methyl alcohol, quinine, or thallium.

Tobacco amblyopia

The scotoma in tobacco amblyopia is generally for green, occasionally for yellow, and rarely for blue. It is central, usually small and oval, but it may extend peripherally from the fixation point to beyond the blind spot.

Detachment of retina and cataract

Blue-blindness occurs in detachment of the retina. Perception of blue is impaired in cases of cataract. Early cataract is said to impart an 'oil lamp effect' to the world of colour.

Injury of calcarine area

When disease or injury affects the calcarine area, complete colour hemianopia may precede complete form hemianopia.

Hysterical amblyopia

In hysterical amblyopia the fields for colour are often reversed. For example, the field for blue may be smaller than the field for red.

6.—THEORIES OF COLOUR VISION

Theories of colour vision are notoriously numerous. Each theory explains some of the facts but none of them explains all the facts. No more than an outline of some of the more prominent theories need be given here.

The duplicity theory of von Kries. There are two separate mechanisms in the retina, namely, the rod mechanism and the cone mechanism. The former subserves twilight (scotopic) vision and is achromatic. The latter is active in the photopic (light-adapted) eye and is polychromatic. *Theory of von Kries*

The Young-Helmholtz or three-components theory. Newton demonstrated the fundamental trichromatic basis of colour mixture. Thomas Young postulated three types of cone in the retina, which, when stimulated by light, give rise respectively to the sensations of red, green, and blue. Each of them is attuned to respond to light of a particular wave-length, but is in a lesser degree responsive to light of other wave-lengths. The retino-cerebral mechanism can thus respond to any colour, pure or mixed. When all three types are excited equally a sensation of white results. Helmholtz elaborated the theory by adding to it the conception of three different activities by each cone initiated by light of the three primary colours. *Young-Helmholtz theory*

Macdougall's theory is a modification of the Young-Helmholtz theory but hypothesizes the existence of an additional and separate mechanism for white. According to this theory, there are separate retino-cerebral mechanisms for white, red, green, and blue. The cortical centres for the two eyes are associated but not identical. *Macdougall's theory*

Roaf's theory assumes the presence of oily globules in front of the retinal cones. These act as filters so that the associated end-organs are stimulated only by those wave-lengths which are not absorbed by the globules. There are three sets of receptors—one for the whole of the visible spectrum, one for long and medium wave-lengths, and one for short wave-lengths. So far, globules have not been demonstrated in a mammalian retina, but they have been found in the retinae of birds. *Roaf's theory*

The opponents theory of Hering rests on a psychological foundation. Black is a separate colour sensation and not merely the result of an absence of physical stimulation. There are three substances in the retina. By the action of light they are constantly being broken down and rebuilt. According as katabolism or anabolism of these three substances occurs, they give rise respectively to the sensations of black or white, yellow or blue, red or green. *Hering's theory*

Edridge-Green's theory introduces an evolutionary conception. The visual purple in the rods is broken down by the action of light. The products of this decomposition vary with the wave-length of the light. They flow towards the macula and stimulate the cones so that an impulse is conveyed to the colour-perceiving centre in the brain. *Edridge-Green's theory*

In its most highly developed form, this centre is capable of differentiating seven essentially different colours. By less highly developed centres, six, five, four, three, two, or only one can be differentiated.

*Ladd-Franklin's
theory*

Ladd-Franklin's theory also has an evolutionary basis. The primitive visual sense was restricted to black-white, i.e. grey, sensations. These were initiated by the action, on the nerve-endings in the retina, of a chemical substance. This substance was liberated by the ether vibrations of the luminous spectrum tearing off the outer atoms of the grey molecule. As evolution proceeded, some of the grey molecules attained the status of colour molecules.

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COMA

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Reference may also be made to the following titles:

ALCOHOLISM	CONCUSSION AND
APOPLEXY	COMPRESSION
BRAIN: VASCULAR	DIABETES MELLITUS
DISORDERS	NEPHRITIS AND NEPHROSIS
CEREBROSPINAL	POISONING, HOMICIDAL
FLUID	AND SUICIDAL

1.-DEFINITION

254.] The most highly specialized functions of the body subserve consciousness, and as specialized functions of the bodily organs are vulnerable to disease, so loss of consciousness is an important symptom not only of disease of the brain, but of many other serious diseases which cause toxaemia, disordered metabolism, or circulatory failure.

Loss of consciousness may occur suddenly or gradually and may vary greatly in degree. Partial loss of consciousness or stupor is said to be present when the patient seems to be asleep, but can be roused for a few moments when spoken to. When the patient cannot be so roused, he is said to be comatose. Degrees of coma may also be distinguished: in the slightest forms the reflex activities, such as the corneal, pupillary, swallowing, and tendon reflexes, are preserved; in severe cases of coma muscle tone is lost, the cornea is insensitive and the pupillary light-reflex is absent. Relaxation of the palate leads to a peculiar stertorous breathing, the respirations may become irregular and shallow, and Cheyne-Stokes rhythm may be present. Accumulation of secretion in the throat and trachea causes a 'rattle' which often indicates impending death.

*Degrees of
coma*

2.-CAUSES OF COMA

*Relative
frequency
of causes*

Solomon and Arling recently found that of the 37,438 cases admitted to the Boston City Hospital in one year 1,167, or 3 per cent, were admitted in coma. Their analysis of the relative frequency of the cases of coma among these 1,167 cases was as follows:

CAUSE OF COMA					PERCENTAGE OF TOTAL CASES	FATALITY RATE
Alcohol	-	-	-	-	59.1	2.0
Trauma	-	-	-	-	13.0	31.5
Cerebral vascular lesions	-	-	-	-	10.1	77.1
Poisoning	-	-	-	-	2.8	9.0
Epilepsy	-	-	-	-	2.4	0.0
Diabetes mellitus	-	-	-	-	1.7	55.0
Meningitis	-	-	-	-	1.7	100.0
Pneumonia	-	-	-	-	1.7	90.0
Cardiac decompensation	-	-	-	-	1.4	70.0
Exsanguination	-	-	-	-	0.9	100.0
Syphilis of the central nervous system	-	-	-	-	0.6	0.0
Uraemia	-	-	-	-	0.6	100.0
Eclampsia	-	-	-	-	0.6	42.8
Miscellaneous	-	-	-	-	3.4	68.4

The miscellaneous group included cases of erysipelas, burns, brain tumour, miliary tuberculosis, carcinomatosis, hypoglycaemic shock, Stokes-Adams syndrome, immersion, syncope, Simmonds's disease, rupture of the urethra, pernicious anaemia, ruptured ectopic pregnancy, leukaemia, cholaemia, strangulated hernia, septicaemia, and empyema. To these varied causes may be added other conditions which cause great increase of intracranial pressure, such as cerebral abscess, chronic subdural haematoma, chronic arachnoiditis, and other causes of hydrocephalus. Pylorospasm in infants may cause coma from hypochloraemia. Acute disease involving the suprarenals, grave diseases of the liver, hypothyroidism, and heat-stroke may also result in coma. To this list might be added many acute diseases in which the development of coma indicates impending death.

Among the possible causes of coma, there are several which require immediate treatment if the patient's life is to be saved. The importance of the early diagnosis of the cause of any case of coma is therefore evident. Simple clinical methods of examination can usually determine the cause of the condition.

3.—METHODS OF INVESTIGATION

(1)—General Examination

When examining the patient it should in the first place be borne in mind that coma may be simulated by an hysterical state. *Signs of an hysterical state* Hysterical stupor resembles peaceful sleep, the breathing may be irregular but is not stertorous. The colour is good and the pulse is normal. The eyes resist opening though the rest of the body may be flaccid; and, if the eyes are forced open, they are found to be turned up in an endeavour to shut out all light. The pupillary and corneal reflexes are normal. Occasionally the eyes show an hysterical spasm of convergence which simulates an internal strabismus; in such cases the pupils are of course small, and, as they are already contracted, will not contract much further on exposure to light. The tendon and superficial reflexes are also normal, the abdominal reflex being often very brisk.

In all cases of true unconsciousness the history is of the greatest importance and urgency, though it is often not available. *History of case* Relatives accompanying the patient, or witnesses of his actions before collapse, should be retained for questioning, for there should be no delay in the investigation of such cases. The medical examiner should make inquiry as to the possibility of alcoholic or other poisoning, head injury, chronic disease of the circulation or kidneys, epilepsy, diabetes mellitus, or hyperinsulinism, previous disease of the central nervous system, or mental depression. Premonitory symptoms, such as drowsiness, vomiting, headache, convulsions, twitching, fever, or paralysis are also of great value in diagnosis.

The manner in which consciousness is lost is often significant. Very

sudden collapse with immediate loss of consciousness usually indicates gross cerebral haemorrhage. The patient sometimes complains of acute pain in the head before losing consciousness. In subarachnoid haemorrhage from a leaking aneurysm at the base of the brain, the very sudden onset of acute pain in the head is striking. Consciousness gradually becomes impaired at an interval after the vessel ruptures, the length of interval and the depth of coma which ensues depending on the amount of haemorrhage. When a large cerebral vessel is blocked by thrombosis or embolism, loss of consciousness may follow rapidly. When the vessel involved is small, or if the obstruction occurs gradually, consciousness is often little impaired though paralysis may result. Loss of consciousness from uraemia or diabetes mellitus is usually gradual, and in the former there is often a history of headaches, drowsiness, twitching, or fits. These examples illustrate the value of investigating the history of the case as far as possible.

The age, state of preservation, and general appearance of the patient will give much information to the experienced observer. For example, the appearance of the patient in cases of pneumonia, exsanguination, eclampsia, or carbon monoxide poisoning is often characteristic.

Clinical examination

Clinical examination may detect many abnormalities in a patient who is unconscious. The degree of unconsciousness can be observed by attempting to arouse the patient to give his name or to carry out some simple instruction. Pinching the skin of the back of the hands, or the calves, will cause withdrawal movements except in deep coma. When no voluntary movement can be stimulated and the corneal and pupillary reflexes are absent, coma is deep. In such cases the breathing is stertorous and may be irregular.

(2)—Temperature, Pulse, and Respiration

The temperature, and the pulse and respiration rates indicate the general condition of the patient, and in some cases throw light on the diagnosis. Profound shock due to injury to the head or other part of the body is readily recognized by the sighing respirations, thready and rapid pulse, subnormal temperature, and the cold, grey or cyanotic skin on which large drops of sweat are visible.

Temperature

High temperature occurs in acute fevers, heat-stroke, and pontine haemorrhage. Some patients with severe head injury die in hyperpyrexia, but others die without any rise of temperature as they are unable to react to the initial shock.

In all cases of severe head injury, an hourly record of the temperature, pulse, and respiration rate should be kept and should be compared with the degree of unconsciousness present. A progressive rise in the pulse and respiration rates is always a sign of the gravest possible significance and when these signs are present operation is useless.

Pulse

Slowing of the pulse is a good sign if the patient is becoming more conscious; a restless patient is more conscious than one who is unable to move. When, however, in cases of head injury, some recovery of

consciousness occurs, but is followed by progressive slowing of the pulse, a slight rise of blood-pressure, and unconsciousness again becoming profound, this indicates progressive increase of intracranial pressure and demands immediate operation. The cause is usually compression of the brain by haemorrhage, possibly from a torn middle meningeal artery. It is obvious that unless such patients are observed carefully, the symptoms of the initial shock may mask those of increased intracranial pressure. Slowing of the pulse, if accompanied by increasingly profound loss of consciousness, is a danger signal which usually demands prompt surgical relief. The development of weakness of one side of the body in such a case indicates that the opposite cerebral hemisphere is being compressed.

(3)—Other Diagnostic Signs and Investigations

(a) *The Breath*

The odour of the breath may suggest the diagnosis in diabetes, in uraemia, and in poisoning from carbolic acid, alcohol, and other aromatic poisons. The odour of stale alcohol in chronic alcoholics is characteristic. The diagnosis of alcoholic poisoning, however, must never be made until other possibilities, such as head injury, have been carefully considered. Alcoholics are liable both to head injuries and to acute infections. Alcohol is often given to those who have collapsed from any cause, and the resulting odour of alcohol may cause a mistake in diagnosis. Further, the various mental reactions to alcoholic poisoning may all be reproduced in post-concussional states. The development of coma following a period of confusion occurs in alcoholic poisoning, but may also occur in head injuries, particularly when the brain is being compressed by haemorrhage.

*Diabetes,
alcohol,
and other
poisoning*

(b) *Injury*

The skull should be carefully examined for evidence of injury, but it is important to note that even in fatal concussion there may not be any sign of injury to the head. Bruising of the scalp, subconjunctival haemorrhage, haemorrhage or escape of cerebrospinal fluid from the nose or ears, may all indicate severe injury. As the patient will be recumbent, the pharynx should be examined for evidence of nasal haemorrhage.

(c) *The Ear*

The ear drums should be examined for evidence of ear disease, or of haemorrhage into the middle ear due to fracture of the skull.

(d) *The Tongue*

The state of the tongue may be helpful in diagnosis in the early stages of the coma. If it is clean and moist, the patient was probably in fair health until shortly before the onset of unconsciousness. If it is dry and furred, the development of coma is probably a symptom

of chronic disease, such as uraemia. An injury of the tongue may have been caused by the teeth during an epileptic fit.

(e) The Eyes

The eyes should next be examined. Conjugate deviation of the head and eyes often occurs in cerebral haemorrhage or thrombosis. The head and eyes are usually turned towards the side of the lesion, but while the lesion is developing the deviation is usually to the opposite side. Slight strabismus is common in all cases of coma and does not usually indicate any interference with the oculomotor mechanism. An enlarged pupil on one side with loss of the light reaction on the same side, however, suggests paralysis of one third nerve, if associated with an external strabismus.

Ocular movements

Though in many stuporous patients it is impossible to test the ocular movements, in some cases information can be obtained by holding the eyes open and rotating the patient's head in different directions. In many cases fixation is maintained in a forward direction, so that the lateral movements of the eyes can be tested by moving the head.

Size of pupils

The pupils are often unequal in cerebrovascular accidents and head injuries, and in such cases the larger pupil is usually on the side of the lesion. The size of the pupils may be significant. Small pupils are found with syphilis of the central nervous system, opium poisoning, and pontine lesions. In other conditions causing coma the pupils are of an average size or are enlarged, but they tend to be small in many cases of uraemia. In alcoholic coma, the pupils may be small, but dilate on pinching the skin. In opium poisoning, on the other hand, the contracted pupils do not dilate in response to this test.

Examination of discs and retinae

Examination of the optic discs and retinae is essential. Papilloedema indicates chronic increase of intracranial pressure, but the discs are often quite normal in conditions which have caused a rapid rise of pressure, such as severe head injuries or cerebral abscess. Occasionally great increase of pressure in a chronic form is unaccompanied by change in the optic discs. The appearance of the retinal vessels is of great value in the diagnosis of disease of the cerebral arteries; albuminuric retinitis may suggest cerebral haemorrhage or uraemia, and diabetes mellitus may cause retinitis. A large sub-hyaloid haemorrhage is occasionally present in spontaneous subarachnoid haemorrhage. The ocular tension should be estimated, as low tension is a feature of diabetic coma and of an incipient hypoglycaemic attack.

(f) Signs of Meningeal Irritation

Neck rigidity

Signs of meningeal irritation should be carefully tested for. Neck rigidity is the earliest sign, but Kernig's sign may also be useful. Rigidity of the neck usually indicates either meningitis or haemorrhage into the subarachnoid space; but it may also be caused by a bruise on the back of the head, or by some injury to the cervical vertebrae which may result from a fall on the head.

(g) *The Central Nervous System*

Examination should now be directed to the detection of hemiplegia *Hemiplegia* or hemiparesis. Weakness of one side of the face may be obvious, and *and hemiparesis* if the mouth and nose are closed by the examiner during expiration, excessive bulging of one side of the face suggests weakness of that side. Pricking the skin of the face or irritating the corneae may produce some grimace which will demonstrate any lack of movement on one side.

If the patient is capable of any spontaneous movement of the limbs, *Hemiparesis* lack of movement on one side suggests hemiparesis, but it is important to keep in mind that inability to move a limb may be due to a local injury, such as a fracture or a tearing of nerve trunks. After excluding a fracture of the limbs, the arms may be held up above the patient's head and allowed to drop suddenly; if this is repeated several times, flaccidity on one side may be obvious even in deep coma, particularly if the arms are held in such a position that they will fall on the patient's face if no resistance is possible.

A suggestion of hemiplegia is often confirmed by the failure of the *Hemiplegia* affected limbs to move in response to pinching the skin or to some other painful stimulus. Loss of tone of the lower extremities may be tested for by flexing the leg and thigh on the abdomen and allowing the extremity to fall on the bed; the two sides may in this way be compared. The response to pinching the calf muscles is often strikingly different in the two legs in cases of hemiplegia. If the disturbance is purely motor, the normal limb will often attempt to remove the noxious stimulus, or the facial expression will indicate that some sensation is appreciated. If, on the other hand, the paralysed side is also anaesthetic, a painful stimulus applied to the affected side does not produce any trace of reaction, whereas some response can usually be obtained from the unaffected side.

Examination of the tendon-reflexes is of relatively little value in coma, *Tendon-reflexes* for they are often all absent. The plantar reflex is of great value in many cases, for although an extensor response may be obtained on both sides in any form of deep coma, an extensor plantar response is often found on one side only in cases of cerebrovascular accidents, and may thus confirm the observations made as to the presence of hemiplegia. Muscular twitchings may indicate uraemia, but they may also occur in other conditions causing cerebral oedema, such as head injury.

(h) *The Circulatory System*

Examination of the heart, blood-pressure, and circulation will usually show whether there is heart disease (a possible source of embolism), arteriosclerosis, or kidney disease.

(i) *Lungs and Abdomen*

The lungs should be carefully examined, especially if the respiratory rate is increased. Examination of the abdomen is important, especially

for evidence of carcinoma, or of disease of the liver or spleen. The bladder should be carefully examined for distension, retention of urine being a common cause of restlessness in cases of head injury. The lymphatic glands should also be examined.

(j) *The Urine*

Urine should be collected by catheterization, and examined for evidence of diabetes mellitus or kidney disease. Gross cerebral vascular lesions, however, may occasionally cause albuminuria or glycosuria. For example, subarachnoid haemorrhage may be followed by 'massive albuminuria', the urine clotting on boiling, for about 48 hours after the onset, when it clears up. Even the estimation of the blood-sugar may fail to clear up the diagnosis, for hyperglycaemia may occur in head injuries and in cerebral haemorrhage. Laboratory examination of the urine and blood may help to establish the diagnosis of alcoholic poisoning (see Vol. I, p. 281).

(k) *Cerebral Haemorrhage*

In some instances it is extremely difficult to diagnose cerebral haemorrhage with certainty. The difficulty may arise when the haemorrhage does not cause hemiplegia, and when it fails to indicate its presence by the appearance of blood in the cerebrospinal fluid; the presence of glycosuria may further complicate the diagnosis. In such cases the haemorrhage is usually in the frontal region, either from a tumour or from an aneurysm of the anterior cerebral artery (see APOPLEXY, Vol. I, pp. 720, 723). If the history of the case is available, however, sudden collapse with or without acute pain in the head is typical of haemorrhage.

(l) *Cerebrospinal Fluid*

*Lumbar
puncture*

Examination of the cerebrospinal fluid is of great importance and should be carried out in doubtful cases. If, however, gross swelling of the optic discs, indicating great increase of intracranial pressure, is present, the withdrawal of more than 2 cubic centimetres of cerebrospinal fluid, and this through a fine-bore lumbar puncture needle, is dangerous. But a manometer reading of the fluid pressure may always be taken, provided that not more than this amount be withdrawn. In conditions which cause a rapid rise of intracranial pressure, such as extradural haemorrhage, brain abscess, and meningitis, papilloedema may be absent even though the pressure is very high.

*Pressure of
fluid*

The pressure of the cerebrospinal fluid may be estimated by attaching a manometer to the needle and noting the height to which the escaping fluid rises (see p. 57). For this test, the patient must be lying horizontally in the lateral position, and care must be taken that he is quite relaxed and that there is no pressure on the jugular veins (as will occur if the head is bent forward) during the estimation. The rate of flow of the fluid from the needle should not be accepted as an

indication of the pressure. In severe head injuries the pressure is often raised, but in some cases is quite normal.

In gross intracerebral haemorrhage rupturing into the ventricles, and in leaking aneurysm, there is so much blood in the cerebro-spinal fluid that it looks like undiluted blood. On standing in the test-tube, however, the fluid will not clot unless there is associated meningitis, and the supernatant fluid is stained yellow. This yellow coloration of the fluid on standing, and the fact that each drop of fluid is uniformly mixed with blood, distinguish subarachnoid haemorrhage from haemorrhage produced by the lumbar puncture needle. A small quantity of blood in the fluid gives it a slight yellow turbidity, but a white turbidity usually indicates infection of the meninges, and is due to the large number of white cells in the fluid.

The cells should be counted and the types of cells determined. The protein content, the Wassermann reaction, the globulin reaction, and the colloid gold curve should be investigated; some of the fluid should be allowed to stand in a test-tube to see if a coagulum forms. The urea content of the fluid, or of the blood, will give information in cases of possible kidney disease (see CEREBROSPINAL FLUID, p. 52). *Other tests*

(m) Gastric Contents

In cases of possible poisoning, the vomit should be retained for examination; the stomach should be washed out without delay and the gastric contents kept for the same purpose. The odour of the gastric contents may indicate the presence of some poisonous substance.

(n) Conclusion

In conclusion, it may be emphasized that, although there are many diseases which cause coma, the cause can in the great majority of cases be determined. Full examination provides the best means of avoiding error in diagnosis, and the practitioner should not rest until every possibility of establishing the diagnosis has been explored.

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COMPENSATION

See INDUSTRIAL ACCIDENTS

COMPRESSED AIR DISEASE

See CAISSON DISEASE, Vol. II, p. 730

COMPRESSION, CEREBRAL

See CONCUSSION AND COMPRESSION, p. 361

CONCATO'S DISEASE

See ASCITES, Vol. II, p. 157; *and* PERITONITIS, CHRONIC

CONCUSSION AND COMPRESSION

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Reference may also be made to the following title:

CEREBROSPINAL FLUID

1.—DEFINITION

255.] Concussion, contusion, and compression are cerebral conditions consequent on head injury, which give rise to clinical manifestations of damage to the brain.

The important factor in injury of the head is the amount of damage to the brain. Fracture of the skull is of little import, except that it may give rise to haemorrhage compressing the brain, and open up pathways of infection. The presence of fracture is evidence of a certain degree of violence although serious cerebral damage may exist without it.

2.—AETIOLOGY OF HEAD INJURY

The state of knowledge of the pathology of cerebral damage is not altogether satisfactory, and it is necessary to mention briefly some of the physical conditions which are involved in its production.

Physical conditions

The sponge-like brain, encased within a rigid skull, possesses a certain amount of independent movement and is subjected to varying degrees of pressure. This pressure, which at the narrow arterial inlet is high

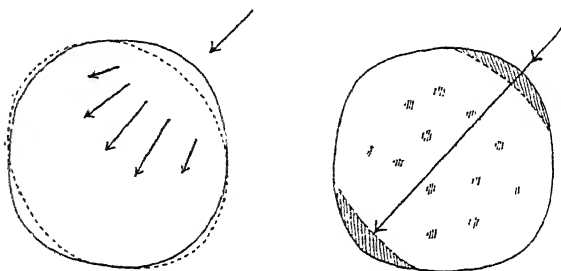


FIG. 44.—Diagrams to show the distribution of force within the skull when the head strikes a flat surface. (*British Journal of Surgery*, 1914–15)

and equivalent to the systolic pressure, gradually falls as the arterial bed widens out into capillaries, and is low when the blood reaches the capacious venous sinuses. Running *pari passu* with this low venous pressure is the cerebrospinal fluid pressure. When the skull receives a blow it is suddenly deformed (see Fig. 44), the contents are momentarily squeezed, and damage results from sudden displacement of cerebrospinal fluid, and from haemorrhage due to rupture of blood-vessels. As the wave of violence passes through the brain it will be broken up by the various dural septa, and its path will be represented by scattered capillary haemorrhages.

(1)—Cerebrospinal Fluid

The part played by the cerebrospinal fluid in this process presents certain anomalies which are not fully understood. Briefly, this fluid is in active circulation, acting both as a water-bed and a flushing system for draining away waste products (see Fig. 45). It is secreted by the choroid plexuses, passes down the narrow ventricular channels, and emerges into the subarachnoid space through three small foramina in the roof of the fourth ventricle. Here, at the base of the brain, the fluid is found in large cisterns, and spreads fanwise over the surface of

the hemispheres to be absorbed into the blood-stream by the Pacchionian bodies along the longitudinal sinus. The fluid also bathes the surface of the spinal cord, and a small quantity can be displaced downwards

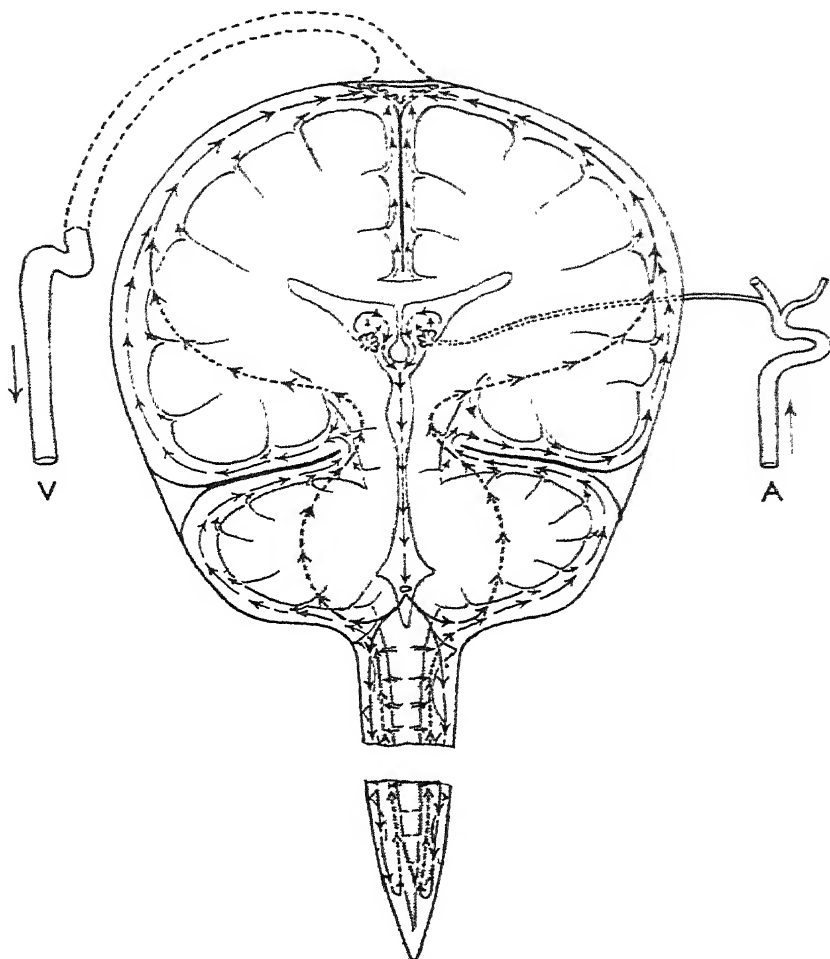


FIG. 45.—Schematic diagram of cerebrospinal-fluid circulation. A. Internal carotid artery giving branch to choroid plexus. V. Internal jugular vein draining superior longitudinal sinus. Main pathway of the fluid is indicated by heavy arrows, passing from roof of fourth ventricle up through basal cisterns and up each Sylvian fissure to reach superior longitudinal sinus. Perivascular drainage from the nervous tissue, and the flushing stream of cerebrospinal fluid over the brain surface, are indicated by light arrows. (*Edinburgh Medical Journal*, 1928)

in this direction. This waterway, when blocked, is capable of developing an intrinsic pressure of its own, and with injury its free circulation is further impeded by the presence of blood in the subarachnoid space and by acute cerebral oedema; this added pressure, especially in the posterior fossa, will force the cerebellum down into the foramen magnum. Such a contingency should always be borne in mind, as

lumbar puncture in these circumstances may lead to fatal results. The factors governing the production and absorption of cerebrospinal fluid in head injury are not known. Haemorrhagic effusion into the Pacchionian bodies is capable of blocking the absorption of cerebrospinal fluid into the blood-stream, leading to a rise in its pressure. Jefferson called attention to the fact that examination of the choroid plexuses reveals changes in the cells and waterlogging of the stroma, which may lead either to an over- or under-production of cerebrospinal fluid. These anomalies in some measure account for the inconsistent low cerebrospinal-fluid pressures which are sometimes encountered. (See Cerebrospinal Fluid, p. 52.)

(2)—Haemorrhage

The other factor giving rise to increased intracranial pressure and cerebral disturbances is haemorrhage. The blood may be extradural, subdural, or intracerebral. Many of these haemorrhages are rapidly fatal.

*Extradural
haemorrhage*

Extradural haemorrhage is the classical picture of middle meningeal

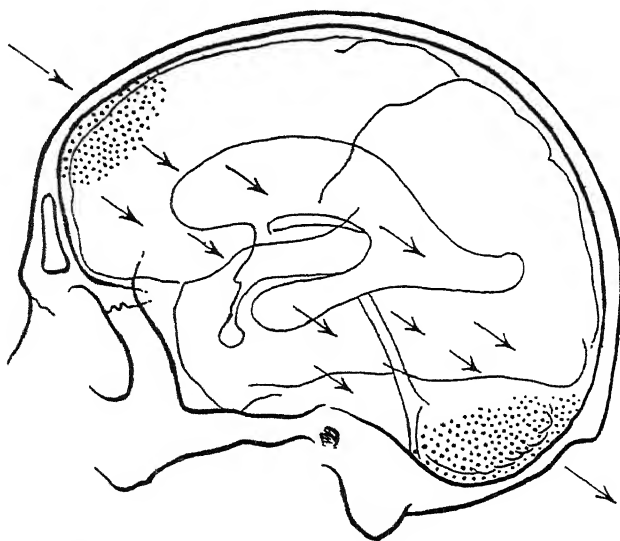


FIG. 46.—Focal contusion with 'contre coup'; wave of violence passing through brain

haemorrhage and gives rise to compression. It is uncommon and the treatment is operative.

*Subdural
haemorrhage*

Subdural haemorrhage is more common than middle meningeal haemorrhage, and, except when it is localized, forms a much less well defined clinical entity. The pia-arachnoid is usually torn and blood then spreads freely into the cerebrospinal spaces. Leakage from the vessels is liable to become chronic and may give rise to pressure symptoms months later (chronic subdural haematoma). This tearing of the vessels in the pia-arachnoid and effusion of blood into the

Contusion

cerebrospinal fluid, associated with oedema of the brain, is spoken of as contusion of the brain. Such contusion may be marked under the site of injury (focal contusion) or even more so at a point diametrically 'Contre coup' opposed (the so-called 'polar contusion' or 'contre coup', see Fig. 46).

(3)—The Effects of Haemorrhagic Pressure

When the pressure of effused blood on the surface of the brain is relatively small, it causes venous compression of the cortical veins, and gives rise to a state of relative anoxaemia. Such a pathological state is associated with symptoms of 'cerebral irritation'. Further, if

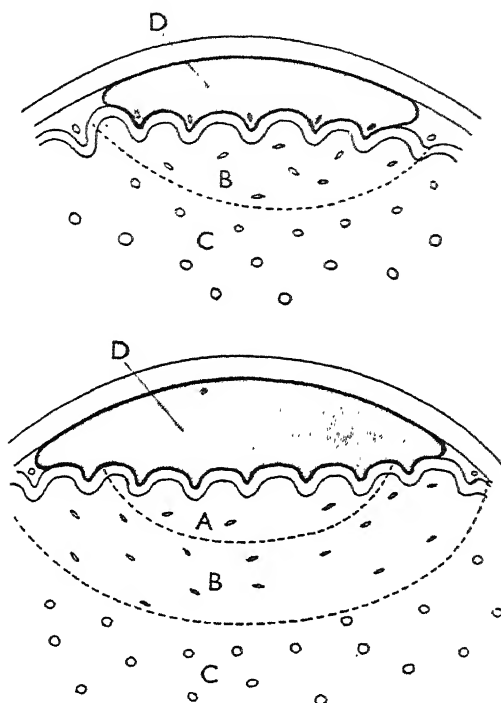


FIG. 47.—Compression of the brain by blood clot. A. Area of anaemia—symptoms of paralysis. B. Area of anoxaemia—symptoms of irritation. C. Area of compensation. D. Clot. (*British Journal of Surgery*, 1914-15)

the underlying brain is subjected to increasing pressure, there will be a corresponding anaemia of its vessels—causing a complete paralysis of its functions (see Fig. 47), with an area of relative anoxaemia beyond.

3.—CONCUSSION

(1)—Definition

Concussion was defined by Trotter as 'a condition of widespread paralysis of the functions of the brain, which comes on as the immediate consequence of a blow on the head, has a strong tendency to spontaneous

recovery and is not necessarily associated with any organic changes in the brain substance'.

(2)—Clinical Picture

Symptoms

At this stage the patient is completely unconscious and in a state of flaccid paralysis, the respiration is shallow, the skin cold and clammy, the pulse rapid, and the blood-pressure low—a condition similar to shock. As a rule, concussion is of short duration and recovery is complete within twenty-four hours. On regaining his senses the patient has a complete amnesia of the interval during which consciousness was lost. In mild cases the effects are momentary; there is a transitory dizziness or loss of consciousness, mental confusion, and physical weakness; but headache may persist for some time. In severe cases watch must be kept for a lucid interval, for unconsciousness following this is not due to concussion.

Recovery

Recovery is ushered in by an orderly march of events. The blood-pressure is raised and the temperature rises, the pulse improves, involuntary movements commence, the reflexes return, vomiting takes place, and on regaining consciousness the patient may ask where he is or answer questions. The recovery of the higher cerebral functions is more varied and may be prolonged. Instead of a rapid return to normal there may be a phase during which consciousness is clouded and there is a lack of inhibitory control, the patient becoming irrational and difficult to manage. Inequality of the pupils, extensor plantar reflexes, rigidity of the neck muscles, and incontinence are sometimes present.

(3)—Theory of Concussion

According to Trotter, concussion is due to a momentary arrest of the cerebral circulation, the brain being squeezed as a result of a blow. This view of an acute compressive anaemia readily explains the rapid and widespread paralysis of the functions of the brain, but it does not explain the fact that recovery is, in comparison, relatively slow. Ritchie Russell tentatively suggested a return to the old 'commotion theory', and regarded this condition, as well as the symptoms of irritation, as due to commotion and molecular change in the neural elements leading to a temporary interruption of their functions.

4.—CONTUSION

Contusion is present when a condition of stupor recurs after the patient has had a lucid interval or has recovered consciousness after concussion. It is evidence of widespread cerebral damage, but occasionally focal signs may be present. Two types of contusion are recognizable.

Major contusion

In major contusion, the patient, instead of making normal post-concussional progress to recovery, remains stuporous, restless, and irritable. He lies curled up in bed, resents interference, is at times

drowsy and at other times noisy and violent. The condition may persist for weeks, but tends to improve with periods of lucidity and of amnesia for the periods during which consciousness is clouded. It is important to distinguish these intervals from the coma of compression.

The salient features of minor contusion are headache, giddiness, and mental disability. These symptoms may follow a major contusion, or trivial injuries in which concussion has or has not been present. Headache may be continuous with exacerbations or it may be intermittent; it is usually located to the site of the injury, and is influenced by alterations in posture and exaggerated by mental, physical, and external causes. Like headache, giddiness is affected by changes in posture. The mental disabilities range from inability to concentrate, indecision, and defective memory, to mental fatigue, brain storms, and insomnia.

*Minor
contusion*

5.—COMPRESSION

Compression is characterized by a lapse into deep coma any time after a lucid interval or the recovery from concussion. The patient is profoundly unconscious and cannot be roused, with classical signs of

*Clinical
picture*

slow stertorous breathing, slow full pulse, raised blood-pressure, and dilated and fixed pupils. It is due to gross intracranial pressure from blood clot, depressed fracture, or the implantation of a foreign body.

Causes

Depending upon its situation, focal symptoms, such as a progressive hemiplegia in the case of a middle meningeal haemorrhage, will develop. If compression is unrelieved, death follows from failure of the bulbar centres.

Prognosis

6.—TREATMENT

(1)—Of Compression

The treatment of compression is immediate operation. With a deeply comatose patient the operation can be carried out under local anaesthesia. An opening is made through the temporal bone by means of a vertical or curved incision. When an extradural haemorrhage is present, the clot is seen at once and should be removed; bleeding points should be tied and it may be necessary to plug the foramen spinosum with a match stick. If the haemorrhage is subdural, a dark-tinged dura will suggest its presence, and it should be evacuated through a small incision in the dura. A small osteoplastic flap allows of a better exposure, depending upon the facilities and experience of the surgeon.

Operation

(2)—Of Concussion

The treatment of concussion is expectant. In a mild case the patient should be kept in bed for ten days to three weeks, and allowed to return to work gradually. Severer cases should be treated for shock: the patient should be put to bed on his side until the swallowing

reflex returns, and warmth should be applied. A more thorough examination should then be made, especially for other injuries, and an hourly record of the pulse, temperature, and respiration kept. The depth of unconsciousness, the reflex responses, the tone of the muscles, the size of the pupils, and the condition of the bladder should be carefully watched. Fluids should be given, rectally if necessary, and sedatives withheld until consciousness is regained.

(3)—Of Contusion

(a) *Treatment of Major Contusion*

If after the recovery of consciousness a concussed patient remains stuporous, he should be treated as a case of severe contusion. The danger signals at this stage are the deepening of unconsciousness, progressive paralysis on one side of the body, slowing of the pulse, stertorous respiration, and inequality of the pupils. There is no doubt that with any such progressive deterioration in the patient's condition, craniotomy should be performed under favourable conditions. Unfortunately, a large proportion of the patients die within a few days, without showing any focal symptoms, death being due to generalized haemorrhage and laceration of the brain. If, on the other hand, the depth of stupor is diminishing, then attention should be directed towards keeping the patient quiet and avoiding undue restlessness and irritability. For this purpose chloral hydrate and potassium bromide (20 grains of each) should be given, or if the patient is unmanageable 3 to 4 fluid drachms of paraldehyde in water at night in addition. Morphine and hyoscine are better avoided as they mask the degree of stupor, and should only be given after the patient has fully recovered from his unconscious intervals.

Drugs

*Regulation of
intracranial
pressure*

Treatment should next be directed towards the regulation of the intracranial pressure. After the first twenty-four hours, if the patient remains stuporous, lumbar puncture should be performed, and the cerebrospinal fluid pressure measured by means of the spinal manometer. If the pressure is above 300 mm. water, lumbar puncture should be repeated daily, or, if lower, every few days, the fluid being allowed to run off till it reaches the normal pressure of 120 to 150 mm. It is not wise to persist in repeated attempts at lumbar puncture in an unruly patient. Few patients are conscious with a red-cell count of over 100,000 per c.c. in the cerebrospinal fluid. Although the mental state of the patient bears no definite relationship to the pressure of the cerebrospinal fluid, the withdrawal of fluid is useful in hastening recovery and relieving headache. The blood-pressure is a guide to the progress of the intracranial tension. Magnesium sulphate is useful for lowering pressure, and may be given by mouth (60 grains hourly) or per rectum (3 grains in 6 ounces of warm water). Far more efficacious are hyper-tonic saline injections, but these should be employed with care in the early stages. They are better suited for those cases in which two or three lumbar punctures have given a reading of over 200 mm. of water. An

intravenous injection of 50 to 100 c.c. of 50 per cent pure glucose in physiological saline or 15 per cent hypertonic saline can be given and, when necessary, repeated every two or three days.

(b) *Treatment of Minor Contusion*

The treatment of minor contusion is guided by the abatement of its symptoms. Rest in bed and quiet should be prescribed in whatever posture gives most relief to headache and giddiness. Aspirin 10 grains, or a powder or cachet containing aspirin 4 grains, phenacetin 4 grains, codeine phosphate $\frac{1}{8}$ grain as in veganin, is useful for headache; if this is severe and persistent, lumbar puncture or intravenous saline should be tried. Soluble barbitone, 5 to 10 grains, for sleeplessness, and a mixture of aspirin 5 grains, amidopyrine 5 grains, and potassium bromide 5 grains, may be given three times a day as a general sedative. As in all cases in which amidopyrine is administered it is important to watch for symptoms of agranulocytosis.

After the patient has been symptom-free for a week he may be allowed up, and a system of graduated convalescence may be imposed; the return to work should be determined for each individual on the basis of his particular symptoms.

(4)—Of Complications

(a) *Scalp Wounds*

After a compound injury to the head, haemorrhage, which may be very free, should be controlled by pressure or suture, and the patient should be sent quietly to a nursing home or hospital. It is only after some degree of recovery from shock that a systematic examination should be carried out and an X-ray of the skull taken. The line of the fracture should be noted to see if it crosses important vessels. In dirty wounds the skin edges should be excised, and bleeding controlled by deep sutures. At the same time the surface of the skull may be examined for fracture. Linear fractures are best left alone, but a limited amount of bone should be removed in depressed fractures to provide adequate drainage.

(b) *Chronic Subdural Haematoma*

Although a rare complication, chronic subdural haematoma should be remembered in people over middle age, because of its occurrence from a few weeks to months after even a trivial head injury. The condition may simulate tumour, showing headache, somnolence, and hemiparesis. Xanthochromic fluid may be present on lumbar puncture.

Burr holes through the skull should be made on either side of the mid-line in the fronto-parietal region, and the dura incised. A greenish clot will be seen, and an attempt should be made to remove it by suction. The condition is frequently bilateral. If the clot is too firmly organized to prevent removal in this way a small osteoplastic flap should be turned down.

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CONJUNCTIVA, INJURIES AND DISEASES

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Reference may also be made to the following titles:

BLINDNESS

CORNEA, INJURIES AND
DISEASES

EYELIDS, INJURIES
AND DISEASES
TRACHOMA

1.-INJURIES

256.] Foreign bodies found in the conjunctival sac may be of the nature of eyelashes, particles of dust, flying fragments of emery, or metal from a workman's tool, flies, or other objects. The eye should be examined in a good light and the foreign body removed by means of a pledget of cotton-wool. The lowest part of the conjunctiva can be easily seen by gently pulling down the lower lid; the uppermost recess of the conjunctiva is less easily examined. A glass rod or some substitute is placed horizontally on the upper lid at the level of the upper limit of the eyeball, with one end at about its middle. The eyelashes are seized with the fingers of the other hand and by this means the edge of the lid is pulled upwards over the rod which at the same time is pressed downwards. This causes eversion of the upper lid, when the rod may be removed. The depth of the recess may be seen if the lower lid is gently pressed on the globe.

*Foreign
bodies*

A foreign body may become embedded in the conjunctiva, or may penetrate both conjunctiva and sclerotic. If embedded in the conjunctiva, it is easily removed by means of a needle or forceps after anaesthetization. If there is any suspicion that the globe has been penetrated, expert advice should be obtained immediately. Anaesthesia of the conjunctiva is obtained by the instillation of a few drops of a solution of cocaine hydrochloride, 4 per cent, repeated several times until the membrane is no longer sensitive.

The after-treatment of these cases is by bathing with physiological salt solution; this can be home-made by dissolving in a pint of boiled water as much table salt as will lie on a sixpence.

Wounds Wounds of the conjunctiva alone are not serious, and need only to be kept clean by bathing with the above-mentioned solution. When the wound is extensive a rupture of the sclerotic should be suspected.

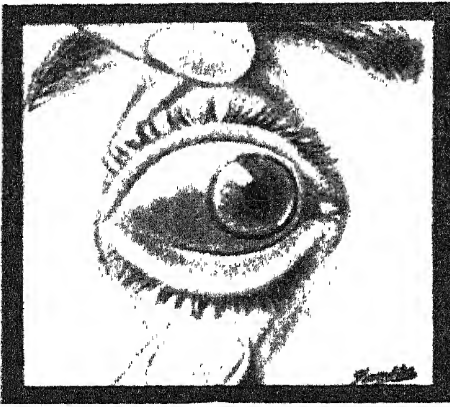
Emphysema In cases involving fracture of the ethmoid, surgical emphysema of the tissues of the orbit may occur and air may appear under the conjunctiva. No treatment of the conjunctival condition is required.

Chemical injuries
Lime-burn Lime-burn is an injury frequently sustained by builders' labourers, who, looking up towards a scaffolding, receive a fall of quicklime between the lids. This injury is usually serious; it is liable to cause extensive burning of the tissues and in the process of healing may result in the partial or complete adhesion of the eyelid to the globe. The immediate treatment is to fill the conjunctival sac with castor oil or liquid paraffin. The sac should not be washed out with water until all foreign matter has been removed. This may be very difficult since quicklime adheres to the conjunctiva, and the insoluble calcium carbonate formed is deposited in the tissues. The frequent application of neutral ammonium tartrate in a 10 per cent solution is recommended to dissolve the deposited calcium.

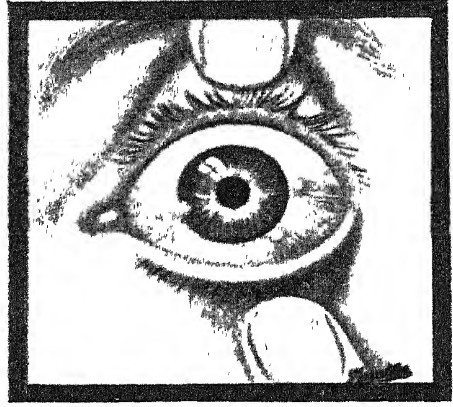
Acid and alkali burns Burns with acids and alkalis frequently occur in school laboratories. The eye should be immediately washed with a large volume of water. Considerable destruction of tissue may result from these burns. In an endeavour to prevent the formation of adhesions between the lids and the globe the conjunctival sac should be filled daily with castor oil, and a blunt glass rod should then be passed into the recesses of the conjunctival sac. The pupil should be kept dilated with a 1 per cent solution of atropine sulphate. Adhesion of the lid to the globe is known as symblepharon and may be dealt with by operation after all inflammation has subsided.

Argyrosis Argyrosis is a black staining of the conjunctiva due to the continued use of silver preparations. It is unalterable.

Atropine irritation Atropine irritation is an inflammation of the conjunctiva with formation of follicles caused by the local use of the drug in susceptible persons. It generally starts in the skin of the lower lid and disappears when atropine is discontinued. When it is necessary to continue its use in a susceptible patient the eyelids may be smeared with castor oil, and one drop of the mydriatic placed in the conjunctival sac, any excess



A



B



C



D

- A.—Ecchymosis of conjunctiva. B.—Phlyctenules of cornea and conjunctiva.
 C.—Pterygium, showing encroachment of conjunctiva on cornea.
 D.—Pinguecula, showing also arcus senilis

PLATE IX

being removed with cotton-wool. When atropine causes irritation other mydriatics, such as solution of hyoscyne hydrobromide $\frac{1}{2}$ per cent. or homatropine hydrobromide 2 per cent, may be tried, but they too may cause a similar irritation.

2.—HYPERAEMIA

Subconjunctival ecchymosis, the spontaneous appearance of a sharply limited red patch of haemorrhage, is not infrequent in persons of middle age. It may occur in healthy people with apparently normal arteries. It may occur in children with whooping cough. After fracture of the base of the skull ecchymosis may appear as the result of blood infiltrating the orbital tissues. See Plate IX. A. *Ecchymosis*

Vascular injection of the conjunctival and deeper vessels may be a sign of an error of refraction, for which the careful prescription of glasses is the cure. *Ametropia*

Hyperaemia of the conjunctiva is often observed in all fevers. It is common in the exanthemata, especially measles, chicken-pox, scarlet fever, and smallpox, and also in dengue. Prophylactic treatment in the form of drops of zinc sulphate solution, $\frac{1}{4}$ per cent, twice a day, may be prescribed, and the lids should be smeared with dilute ammoniated mercury ointment, 2 per cent, at night. *Pyrexia*

Hyperaemia of the conjunctiva which does not yield to ordinary treatment is sometimes associated with oral sepsis. *Oral sepsis*

3.—INFLAMMATION DUE TO BACTERIAL INFECTION

Inflammation of the conjunctiva may be caused by various bacteria, among which are the streptococcus, the staphylococcus, the bacillus of Koch-Weeks, the diplobacillus of Morax-Axenfeld, the pneumococcus, the gonococcus, and the diphtheria bacillus. Each of these organisms may cause an acute or a chronic conjunctivitis. The attack may start acutely, or beginning as a chronic inflammation may develop into an acute condition. Some of these bacteria cause a conjunctivitis with special features; these will be mentioned later. It is, however, often impossible to distinguish clinically between them.

In acute conjunctivitis the eyelids become hot and irritable, often suddenly. A slight discharge appears, first at the inner canthus, and rapidly increases in amount. The conjunctiva at first shows a general injection of the superficial vessels, but this soon becomes more marked, and the membrane becomes oedematous. The eyelids become swollen and it may be difficult to open them. The conjunctival oedema around the corneal margin causes a ridge with a ditch towards the cornea, in which pus collects; here ulceration may occur. Any slight abrasion of the superficial corneal epithelium allows access of bacteria to the *Acute conjunctivitis*

corneal tissue and an ulcer results. In very severe cases a membrane forms on the surface of the conjunctiva owing to the rapid necrosis of the superficial cells.

Treatment

Treatment should be started early if complications are to be avoided. A 2 per cent solution of silver nitrate should be swabbed daily on the everted lids by means of a pledget of cotton-wool twirled round the end of a glass rod or a wooden match. If it is impossible to evert the upper lid, a canthotomy must be done. Thereafter the conjunctival sac should be irrigated every four hours by a gentle stream of freshly made eusol diluted 1 in 10. A little soft paraffin or other ointment should be placed on the edges of the lids to prevent their adhering.

If the practitioner cannot swab the lids with silver nitrate solution, the next best course is to drop into the conjunctival sac daily two drops of a solution of acriflavine in castor oil, 1 in 1,500. The very greatest care must be taken to prevent injury to the cornea when the lids are manipulated.

Chronic conjunctivitis

In every case of a mild inflammation of the conjunctiva a careful search must be made in a good light, using a magnifying lens, for misplaced eyelashes. These may be removed with epilation forceps but they will grow again. They should be dealt with by electrolysis or diathermy if not more than four or five; if more than that an operation is required.

Chronic conjunctivitis in some cases may be due to nasal disease or oral sepsis. The conjunctiva becomes hypertrophied, the tarsal plate of the lower lid becomes thickened, and the lower lid may become permanently everted; this condition, known as ectropion, requires operation.

The symptoms of chronic conjunctivitis are itching and discomfort of the lids. The signs are the injected superficial vessels and a bead of discharge at the inner canthus.

Treatment

The treatment is the removal of nasal disease or of oral sepsis. In children a chronic conjunctivitis may be associated with enlarged and septic tonsils requiring enucleation. Local treatment consists in the instillation of drops of zinc sulphate, $\frac{1}{4}$ per cent, or zinc chloride, $\frac{1}{2}$ per cent, or freshly prepared mild silver proteinate (argyrol) solution, 20 per cent. A little ointment may be put on the lids at night to prevent their sticking together.

Special forms of conjunctivitis

Special forms of conjunctivitis include ophthalmia neonatorum, gonococcal conjunctivitis of adults, diphtheritic conjunctivitis, and angular conjunctivitis.

Ophthalmia neonatorum

According to the Public Health of England Statutory Rules, 1926 No. 971 and 1928 No. 419, all cases of purulent discharge from the eyes of an infant beginning within twenty-one days of birth must be notified to the nearest Medical Officer of Health. Clinically, however, unless the infant's eyes show signs of inflammation within four days of birth the infection cannot have been acquired during the passage of the head through the vagina.

The discharge is noticed about the second or third day after birth;

the lids are red and swollen and exude pus. Unless treatment is started immediately there is grave risk of corneal ulceration and resultant blindness.

Although the condition is usually caused by infection of the maternal vagina by the gonococcus, any of the pyogenic organisms if sufficiently virulent may create a similar clinical condition.

The treatment has been outlined above. For a case in private practice two special nurses are required.

Prophylaxis is effected by treating before delivery any affection of the vaginal mucous membrane which causes a discharge. As soon as the head of the infant is born the eyelids should be cleansed with clean cotton-wool. The water used in the child's first bath must not be allowed to enter the eyes: separate water and towel must be used for the child's face. Then a drop of a 1 per cent solution of silver nitrate, from a bottle free from any precipitate, should be instilled into each eye. This is not to be repeated.

Gonococcal conjunctivitis of adults is the result of direct infection of the conjunctiva by the fingers with gonococci from the genital passages. It often affects only one eye, in which event it is important to protect the other eye from infection by means of a Bullar's shield or by transparent cellulose tissue (cellophane). The sudden onset, copious discharge, oedema of the lids, and severe discomfort should cause immediate examination of the genital passages to be made. The general trend of the disease has already been described under acute conjunctivitis. The course depends on the virulence of the gonococcus, on the efficacy of the defensive mechanism of the conjunctival phagocytic cells and of the lacrimal secretion (which contains an anti-bacterial substance called lysozyme), and on the general health of the patient. Too often ulceration of the cornea occurs, with results which are considered under the title CORNEA, INJURIES AND DISEASES, p. 426.

*Gonococcal
conjunctivitis
of adults*

Diphtheritic conjunctivitis, due to infection with the Klebs-Loeffler bacillus, may be either acute or chronic. In a fulminating form membranes form quickly on the mucous membrane and the eye may be rapidly destroyed. It may occur in the absence of faucial diphtheria, in which event it can be diagnosed only by bacteriological methods. The usual serum treatment must be given in addition to local treatment.

*Diphtheritic
conjunctivitis*

Angular conjunctivitis is a slight persistent redness at the inner canthus due to an infection by the diplobacillus of Morax-Axenfeld. It is quickly cured by a few instillations of zinc sulphate solution, $\frac{1}{4}$ per cent.

*Angular
conjunctivitis*

4.—NON-BACTERIAL INFLAMMATION

Inclusion conjunctivitis of the new-born begins between the second and tenth day after birth. It is usually binocular but occasionally may affect one eye only. There is a discharge from the eyes, and the mucous membrane is hyperaemic and thickened. The cornea is never affected.

*Inclusion
conjunctivitis
of the new-
born*

The increased tearing may persist for a month or so, in spite of treatment. The character of the condition can be made only if several bacteriologic examinations prove the absence of pathogenic bacteria. Since it is not always easy to get expert examinations made this condition is rarely diagnosed. The treatment is by scrubbing the everted lids with silver nitrate solution, 1 per cent, and by frequent irrigations with physiological saline solution.

*Follicular
conjunctivitis*

Follicular conjunctivitis is common in children, and is characterized by the formation in the lower recess of the conjunctiva of small round dots, which are lymphoid aggregations in the subepithelial layer. There is a little discharge but not much discomfort. The condition is essentially chronic, the so-called follicles persisting for months without changing. The disease is usually associated with feeble health, enlarged tonsils, and insanitary habitations. The treatment is to improve the sanitary conditions, at any rate temporarily, e.g. by sending the child to a seaside convalescent home, to give extra vitamins, and to remove the tonsils if they are diseased.

*Diagnosis
from
trachoma*

It is sometimes mistaken for trachoma, an infinitely more serious condition. This should not occur, for in trachoma the follicles, although similar in appearance, are seen on the upper tarsal conjunctiva, whereas in follicular conjunctivitis they are almost entirely in the lower recess of the conjunctiva. Further, in trachoma vascularization of the upper corneal periphery can always be detected by examining in a good light with the help of a corneal loupe.

*Phlyctenular
conjunctivitis*

Phlyctenular conjunctivitis is characterized by the presence of small greyish pimples or nodules on the conjunctiva of the globe, never on the palpebral conjunctiva. They are generally situated near the corneal margin, and in the lower and outer quadrant. A phlyctenule consists of a dense aggregation of leucocytes. There is a little vascular congestion around the nodule; when general conjunctival congestion is present there is in addition a bacterial infection. The epithelial covering may be destroyed with formation of a small ulcer. Phlyctenules are also liable to occur on the cornea, when the condition becomes much more serious. See Plate IX, B.

The disease is usually met with in children of from five to ten years of age who have rhinitis or enlarged tonsils and adenoids, and resulting glandular enlargement in the neck. Signs of tuberculous infection may be present. The first attack often follows measles.

In the absence of extension of the disease to the cornea the symptoms are not very severe. There is usually increased lacrimation, and some muco-purulent discharge. There may be some photophobia and spasm of the orbicularis muscle.

Treatment

The disease usually occurs in children who live in unhealthy surroundings. A careful examination of the general state of health, especially of the nasopharynx, should be made, and treatment directed to any pathological condition found. The local treatment is by using an antiseptic lotion such as freshly prepared eusol diluted 1 in 10, or

mercuric chloride lotion 1 in 5,000, or potassium permanganate 1 in 8,000. In addition yellow oxide of mercury ointment 2 per cent should be used, a bead being placed between the eyelids once or twice a day.

Vernal conjunctivitis or spring catarrh is a chronic form of conjunctival hypertrophy which is extremely resistant to treatment. Diagnosis depends on microscopical examinations of scrapings of the mucous membrane, which, when stained for half an hour in weak eosin solution, show an excessive number of eosinophil cells. *Vernal conjunctivitis*

There are two types of the disease, the palpebral form in which the conjunctiva of the upper lid hypertrophies and becomes mapped out into polygonal raised areas like cobble stones, and the bulbar form in which there is a gelatinous thickening of the conjunctiva around the cornea, sometimes slightly pigmented.

The prominent symptom is an acute irritation of the eyelids, which comes on in the spring of each year. The physical changes persist during the colder weather, but the symptoms become acute as the weather becomes warmer.

The flat-topped nodules are composed of hard fibrous tissue. The condition may be mistaken for trachoma, but the peripheral corneal vascularization characteristic of trachoma is absent, and the hardness of the nodules is quite unlike the softness of the trachomatous follicles.

Treatment is extremely unsatisfactory. No cure is known, and treatment must therefore be directed towards the relief of symptoms. Regular instillation of drops of zinc sulphate solution, $\frac{1}{4}$ per cent, may be employed, and may be combined with adrenaline hydrochloride solution in varying strengths. Drops of very dilute acetic acid (5 drops of dilute acetic acid in 10 c.c. of water) may be tried. Massage with ammoniated mercury ointment 2 per cent, or with yellow oxide of mercury ointment 2 per cent, may be used. Radium therapy may cure the condition but is dangerous on account of the possible development of cataract subsequently. If the palpebral hypertrophy is very prominent the operation of tarsectomy with removal of the conjunctiva overlying the tarsus may be carried out, but this operation is justifiable only when the condition is severe and when the operator has special experience of lid operations. Some sufferers, who can afford the expense, find relief by living always in the cooler parts of the world. *Treatment*

Swimming-bath conjunctivitis is an inflammation of the conjunctiva, which may be either acute or chronic, characterized by the appearance of follicles, and a certain amount of conjunctival hyperaemia and discharge. It is contagious, and is contracted from contact with the infected water of a swimming-pool, or from infected fingers or towels. *Swimming-bath conjunctivitis*

No specific bacterial organism is responsible, but microscopically cell inclusions of a special character may be present. The condition may last for two months.

The treatment is by application of 1 per cent silver nitrate solution, and frequent instillations of $\frac{1}{4}$ per cent zinc sulphate solution. *Treatment*

Xerosis of the conjunctiva and its association with keratomalacia are *Xerosis*

discussed under the title DIETETIC DEFICIENCY DISEASES, in the section dealing with hypovitaminosis A.

A cicatricial process following trachoma, resulting in extreme drying of the conjunctiva, is not uncommon in trachomatous countries. Yet another form of xerosis may occur as a result of ectropion or proptosis, when the globe of the eye is unprotected owing to incomplete closure of the lids.

*Essential
shrinking of
conjunctiva*

Essential shrinking of the conjunctiva resulting in partial adherence of the lids to the globe may occur as the result of syphilis or pemphigus. I have under operative treatment a man who has suffered from syphilis, in whom all four lids are adherent to the globe and inverted so that the lashes play on the cornea. The treatment, other than operative for entropion, is purely symptomatic.

Trachoma

Incidence

Trachoma is becoming rare in England owing to the general improvement of sanitary conditions. It is still common in Southern Ireland, is widespread in some parts of Central Europe and in India, and is universal in Egypt, Palestine, Syria, and China. Sporadic cases appear in every part of the world. At the time of writing I have under my care the following trachomatous patients, other than those met with in hospital practice: two medical men who have never been out of England, and who have never recognized a case of trachoma during their professional career; a boy at one of the Public Schools of England, who became infected while attending as a day-boy a school for British boys in one of our African territories; and two girls at expensive English schools, in whose cases the sources of infection cannot be determined. In the present section an outline of the disease as seen in England is presented, a further description of its varieties and complications being given under the title TRACHOMA.

Definition

Trachoma is a specific contagious disease of the conjunctiva. It is characterized by the new formation of lymphoid tissue which spreads to the cornea and to the tarsus. It is followed by cicatricial changes in the affected tissues. It runs a chronic course.

Synonyms

The disease is also known as granular conjunctivitis or granular lids.

To become infected a healthy person must receive into his conjunctival sac a drop of the discharge from the eye of an individual whose eyes are affected with an active stage of the disease. Such a drop may be conveyed by the finger, by ablutionary water, by a towel or handkerchief. The minimum period which elapses between infection and recognition of the disease is four days; it is, however, usually much longer before a diagnosis is made.

In the first stage of the disease slight roughnesses are found at the extremities of the upper borders of the tarsus of the upper lid. These form tiny greyish islets which are semi-transparent. These are lymphoid follicles. As the condition progresses the tarsal conjunctiva becomes faintly granular and velvety owing to the formation of minute papillae. About the same time examination of the upper corneal periphery with

a corneal loupe or a magnifying glass shows a grey zone through which an extension of the superficial conjunctival vessels invade the clear cornea.

Subsequent changes in the conjunctiva and in the cornea then develop. Bleb-like excrescences appear in the tarsal conjunctiva which, when squeezed, or when the thumb-nail is pressed over them, burst, ejecting gelatinous matter. At the same time the corneal vascularity increases, forming a layer between the corneal epithelium and Bowman's membrane. This produces some opacity of the cornea. In long-standing cases the corneal vascularity or pannus is a prominent feature, and is beyond the scope of treatment.

The gradual absorption of the follicles invariably leads to cicatricial changes in the conjunctiva and to thickening of the underlying tarsus. Owing to its shape the thickening of the tarsus leads to inversion of the lid margin, when cicatrization of the inflammatory exudation, or entropion, occurs. The increased vascularity of the margin of the lid may lead to increased proliferation of the hair follicles, or trichiasis.

There has not been any improvement in the methods of treatment *Treatment* during the last thirty years. In the earliest stage the everted lids should be swabbed daily with silver nitrate solution 2 per cent, but this should not be continued for more than a fortnight or a permanent deposit of black silver may be deposited in the deeper layers of the conjunctiva, a condition known as argyrosis. Then a collyrium of a solution of zinc chloride $\frac{1}{2}$ per cent, or of zinc sulphate $\frac{1}{4}$ per cent, may be instilled two or three times a day. Under this treatment absorption of the lymphoid infiltration may occur. When bleb-like excrescences appear which rupture on pressure they should be thoroughly evacuated by squeezing with Graddy's forceps or by scraping with a sharp spoon. This mechanical treatment may be carried out in adults under local anaesthesia by instillation of cocaine hydrochloride solution 4 per cent, and infiltration of the lids with solution of procaine hydrochloride (novocain) 1 per cent, or some similar drug; for children a general anaesthetic is required. This should be followed by massage of the conjunctiva with mercuric chloride solution 1 in 500. The subsequent treatment is by bathing the lids with some antiseptic lotion, and the instillation twice a day of zinc chloride solution $\frac{1}{2}$ per cent, while every night a little ointment should be placed on the lids to prevent their sticking together in the morning. This mechanical treatment requires repetition three or four times at intervals of a week. Later drops of copper sulphate solution 1 per cent may be employed. Copper citrate ointment 5 per cent is sometimes of value. The old-fashioned copper stick may be used carefully but is painful; it is better to swab the everted lids with copper sulphate solution 5 per cent. No silver compounds other than silver nitrate are of value. The solid silver nitrate stick should never be used, since it may cause excessive scarring.

5.—TUMOURS AND PSEUDO-TUMOURS

- Pterygium* Pterygium is a triangular encroachment of the conjunctiva onto the cornea, at its nasal edge; sometimes a similar encroachment occurs additionally at its temporal edge. Thus the condition appears on the part of cornea corresponding to the interpalpebral fissure (see Plate IX, c). Its origin is due to irritation by wind and dust. If undisturbed the pterygium may become arrested spontaneously, but more usually it grows still further over the cornea giving an unpleasant appearance or even in advanced cases interfering with vision.
- Treatment* Treatment is purely surgical. The neck of the pterygium is seized with toothed forceps, a squint-hook is forced underneath and the head is separated from the cornea. The head is then tucked under the conjunctiva and fixed there by a suture. Great care must be taken that the raw area left is not in contact with conjunctiva or there may be recurrence.
- Pinguecula* Pinguecula is a little yellowish elevation at the corneal margin in the same position as a pterygium, to which it is not related. It is not of any pathological significance, but may be removed if desired for the sake of appearances (see Plate IX, d).
- Lymph-angiectasis* Dilatation of lymph spaces often results in the formation of little cysts. They may be snipped with scissors.
- Angioma* An angioma, usually situated in the neighbourhood of the internal commissure, may be a subconjunctival prolongation from a palpebral angioma or naevus. The condition is congenital. The decision as to whether the treatment should be by ablation, electrolysis, or electro-coagulation may be difficult.
- Dermoid tumour* Dermoid tumour is a flat solid growth attached to conjunctiva and cornea. It is congenital, is liable to extend, and requires ablation.
- Cysticercosis* In some countries large cysts formed by the cysticercus beneath the conjunctiva are met with (see CYSTICERCOSIS, p. 525). There is a nodular protuberance beneath which the cyst is movable. The conjunctiva may be split with scissors and the cyst dissected out.
- Papillomas* At the inner canthus may occur papillomas, which have the appearance of a cockscomb. They are caused by the irritation of inflammatory processes. They should be removed with scissors.
- Limbal tumours* Tumours which appear at the junction of the conjunctiva and cornea, the so-called limbus, are not very common but are of the greatest importance. During the last thirty-five years 18 cases have been reported to the Ophthalmological Society of the United Kingdom; two of these—one a pigmented mole and the other a papilloma—occurred in children. Of the remaining 16 cases 15 were malignant, epitheliomas, or in a few cases sarcomas, and one consisted of lymphatic tissue. In 1920 I saw 10 cases of limbal tumour selected from 108,113 patients in Egypt, of which eight were epitheliomas, one was an endothelioma, and one a papilloma; in each case the diagnosis was made by microscopy after

excision of the eye. It therefore appears that for practical purposes all limbal tumours in adults are of a malignant nature and should be treated as such. In children a limbal tumour is likely to be a papilloma, a pigmented mole, or a congenital dermoid tumour. See Plate X, A.

*Treatment
of limbal
tumours*

The treatment of pterygia, pingueculae, papillomas, and cysts has already been indicated. The treatment of limbal tumours proper is entirely different since they are almost invariably epitheliomatous and malignant. At an early stage most epitheliomatous tumours can be entirely destroyed by radium. In view of the risk of producing metastases it is inadvisable to remove a portion of the tumour for microscopical examination. The tumour should not be cut into or cauterized. In a recent case three radon seeds, each of 1·5 millicuries, screened by 0·3 mm. of platinum, were inserted horizontally under the superficial layer of the conjunctiva and over the site of the tumour, and left for three days. This treatment was followed by disappearance of the tumour but it is too early yet (four months after the treatment) to state if a cure has been effected. The danger of producing cataract by the use of radium near to the eye must be borne in mind. When a limbal growth is no longer entirely superficial, but has infiltrated the surrounding conjunctiva and the sclera, the orbit should be exenterated. As in all cases in which the operation of exenteration is performed the free borders of both lids should be removed.

6.—DEGENERATION

Little grey spots on the conjunctiva of the upper or the lower tarsus are often seen in people of mature years. They contain either chalky concretions or a milky fluid. They may cause some discomfort, and should be treated by evacuation of their contents after opening with the point of a scalpel under anaesthesia produced by instilling cocaine hydrochloride solution, 4 per cent.

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CONSTIPATION

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1.—DEFINITION

257.] Constipation is a functional disorder in which none of the residue of the food taken during one day is excreted within the next 48 hours.

2.—AETIOLOGY

Age and sex incidence Constipation is not uncommon in infants, but is rare in children; it is common in young women, but rare in young men. Its incidence in both sexes is greatest after middle age, but at all ages its incidence is far greater among females than males.

3.—PATHOGENESIS

Types of constipation Constipation may be due to (1) delay in the passage through the colon whilst defaecation is normal—i.e. colonic constipation; (2) inadequate performance of the evacuation from the pelvic colon and rectum—i.e. dyschezia. The small intestines take no part in constipation, even chronic obstruction of the small intestine giving rise to diarrhoea and not to constipation.

(1)—Colonic Constipation

When the colon is watched with the X-rays no movements can be recognized under ordinary conditions, as propulsive movements occur only three or four times a day and the churning movements are so slow that they can be recognized only by comparing radiograms taken at intervals of a minute or more. The contents of the colon are conveyed from the ascending colon to the pelvic colon by 'mass peristalsis' in response to the gastro-colic reflex which occurs when food enters the stomach. The ascending colon is then emptied in order to allow the entry of the contents of the terminal ileum, in which much of the digestion and absorption of food takes place. The faeces are conveyed as far as the pelvi-rectal flexure, where their further progress is prevented by the valvular fold of mucous membrane which separates the movable pelvic colon from the fixed rectum. The pelvic colon, which gradually fills from below upwards, thus acts as a storehouse of the faeces, whilst the rectum remains completely empty.

Radiological findings

The haustration of the colon seen with the X-rays does not, as was formerly believed, correspond with the external haustration seen in the exposed colon, which depends upon contraction of the muscular coats, but represents phases in the constant movements of the mucous membrane brought about by the muscularis mucosae. By bringing successive portions of the soft faeces into contact with the mucous membrane the latter movements promote absorption of water and gradually convert the faeces into the form and consistency in which they are eventually passed.

Delay in the passage through the colon may be due to (a) deficient motor activity, or (b) excessive force being required to carry the faeces to the pelvic colon.

Causes of delay in colon

(a) The motor activity of the colon is deficient when the food contains too little indigestible residue and when an insufficient quantity of faeces is formed on an adequate diet ('greedy colon'). Constipation in the aged and in conditions associated with prolonged malnutrition is probably due to atrophy of the intestinal musculature. Vitamin deficiency is perhaps an additional cause in under-nourished people. In hypothyroidism the normal stimulation of the colonic activity by the thyroid secretion is deficient and constipation occurs; this is one of the causes of the constipation common at the menopause. The gastro-colic reflex, which is the chief stimulant of colonic peristalsis, may be inhibited through sympathetic nervous activity brought about by depressing emotions, and reflexly in painful disease and injuries of any part of the body, particularly the abdominal and pelvic viscera.

Deficient motor activity

In individuals with an abnormally excitable visceral nervous system, irregular contractions induced reflexly by the presence of hard faeces in the colon may exaggerate constipation due to other causes. In intestinal carbohydrate dyspepsia, in which constipation often alternates with diarrhoea, spasm may result from irritation by organic acids, and

it is a constant symptom of diverticulitis. Chronic lead poisoning and the nicotine absorbed in excessive smoking also give rise to spastic constipation.

*Lack of
sufficient
force*

(b) The work to be done by the colon is excessive, and constipation is likely to occur, when the faeces are abnormally dry—a condition which may result from insufficient consumption of water, from excessive excretion in the urine (in diabetes mellitus and diabetes insipidus) and in the sweat (in very hot weather), and from diminution of the intestinal lumen by spasm or an organic stricture.

(2)—Dyschezia

*Determinants
of normal
defaecation*

Normal defaecation depends on a conditioned reflex. The infant is trained to open his bowels when he is put on a chamber, no mental process being concerned in the act. In the course of time there develops an elaborate conditioned reflex in which getting up, a bath, dressing, breakfast, and finally sitting down with a newspaper and a pipe in the familiar w.c. take part—as a result of which the biggest wave of mass peristalsis of the day occurs, the whole colon being involved (see Fig. 48). Distension of the pelvic colon produces discomfort in the lower abdomen, but distension of the rectum produces a perineal sensation which is the normal 'call to defaecate'. When, as a result of the conditioned reflex just described, the faeces which have collected in the pelvic colon during the previous 24 hours enter the rectum, which is always empty except just before defaecation, they give rise to the call to defaecate. The diaphragm and abdominal wall are then voluntarily contracted; and the rise in pressure within the rectum calls forth the final reflex, which results in contraction of the rectum as a whole with relaxation of the anal sphincter, through which the faeces are evacuated.

*Causes of
dyschezia*

Many cases of constipation formerly regarded as colonic are caused by inefficiency of the conditioned reflex, which should result every morning in the partial evacuation of the contents of the proximal part of the colon into the pelvic colon and of the contents of the pelvic colon into the rectum. In the more obvious and common cases of dyschezia this conditioned reflex is unimpaired, but for various reasons it is not followed by the defaecation reflex proper, in which the rectum contracts and the anal sphincter relaxes, so that the rectum is found to be packed with faeces at whatever hour it is examined. Dyschezia often originates in neglect to respond to the call to defaecate owing to laziness, insanitary conditions of the w.c., or false modesty. The double reflex is progressively impaired; the rectum dilates so that an increasing quantity of faeces is needed to attain the adequate internal pressure required to produce the call to defaecate; and finally the sensation is lost completely. The patient, however, is still capable of emptying his rectum if he tries, but by now he has generally convinced himself that he cannot get his bowels opened unless he takes enemas, or such enormous doses of aperients that the fluid faeces act as enemas

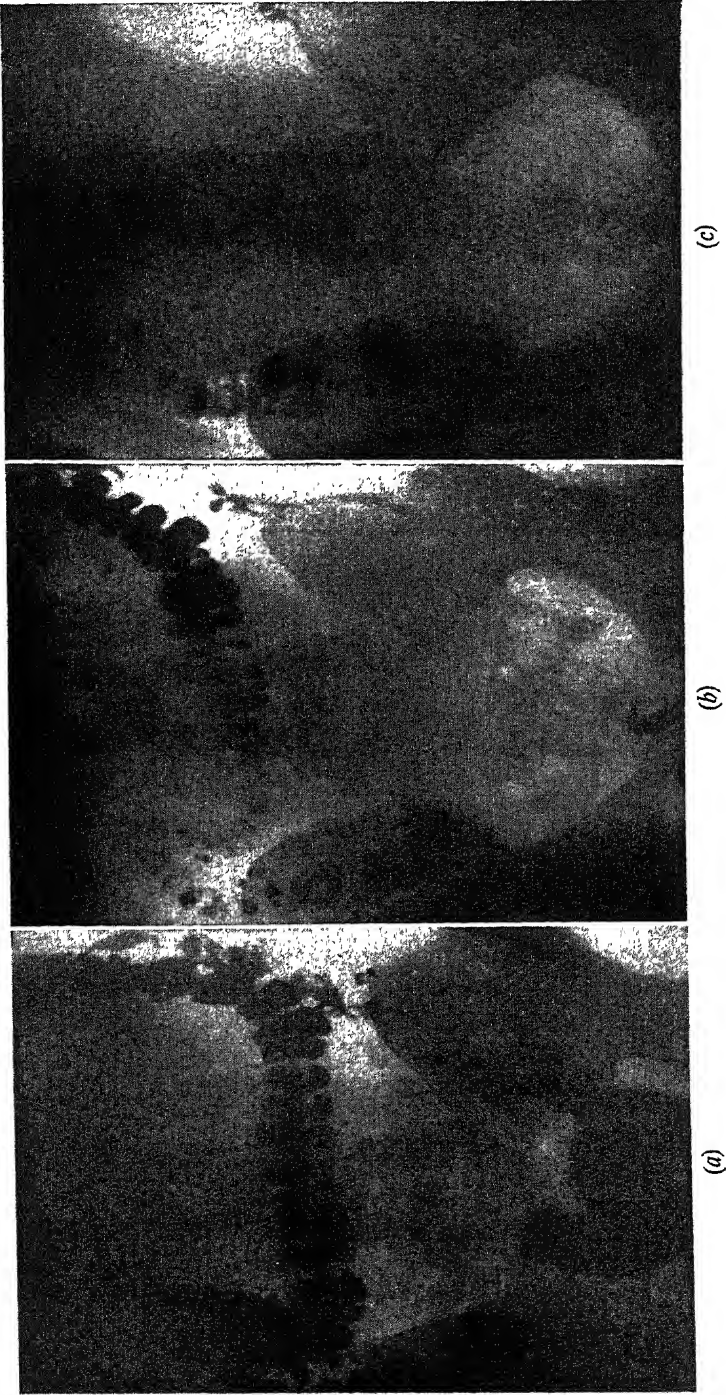


FIG. 48. — Radiograms showing results of defaecation in normal man: (a) 9.15 a.m., before defaecation—barium was taken the previous evening; (b) 9.25 a.m., after first defaecation; (c) 11.20 a.m., after second defaecation. (Dr. P. J. Briggs) (*Lancet*, 1935)

and require no effort for their evacuation. He suggests to himself that his rectum is powerless to act by itself; the dyschezia is thus in part hysterical.

*Loss of
defaecation
reflex*

Dyschezia may be due to other causes, such as weakness of the voluntary muscles of defaecation, the assumption of an unsuitable posture during defaecation, and voluntary inhibition from fear of pain in diseases of the anal canal. But whatever the primary cause, the final result is the same. The defaecation reflex is lost, and the incomplete evacuation of the rectum results in the accumulation of faeces and consequent dilatation of the rectum.

Neglect of the training required to develop this defaecation reflex is the chief cause of constipation in infants; possibly in some cases there is a congenital deficiency of the muscle-sense of the rectum. Thus in most cases the slight additional distension produced by the introduction of a finger or a piece of soap into the rectum results in an adequate stimulus, and defaecation occurs.

The rectal muscle-sense is abolished or defective in diseases of the spinal cord in which the defaecation centre or the fibres connecting it with the brain are involved.

4.—CLINICAL PICTURE

*Constipation
and auto-
intoxication*

A great number of symptoms have been ascribed to the auto-intoxication caused by constipation. But intestinal auto-intoxication is generally the result of artificial diarrhoea induced by the use of aperients taken to relieve the constipation. Under normal conditions very little undigested protein, carbohydrate, or fat reaches the caecum; the small amounts of toxic products of bacterial activity absorbed from the colon and ascending colon are rendered innocuous by the liver or are rapidly excreted by the kidneys. In the comparatively rare cases of constipation in which there is a considerable degree of stasis in the proximal part of the colon, bacterial activity is hardly greater than under normal conditions, as the quantity of food which escapes digestion and absorption in the small intestines is not increased. In dyschezia the faeces in the pelvic colon and rectum are solid, so that very little bacterial decomposition can take place however long they are retained; moreover, absorption can only take place from that part of the surface of the scybalæ which is in contact with mucous membrane. This is in contrast with what occurs in the proximal colon, where the churning caused by the activity of the muscularis mucosae brings all the contents into intimate contact with the mucous membrane. On the other hand, most aperients hasten the passage of chyme through the small intestine so that an abnormal quantity of undigested food and water reaches the colon, which is consequently filled with fluid or semi-fluid material. Here putrefaction and fermentation are active, and the more or less toxic products are readily absorbed by the mucous

*Effect of
aperients*

membrane. Fortunately, in most healthy people the liver and kidneys are able to deal with the absorbed toxins so efficiently that toxic symptoms do not occur. If, however, aperients are taken in excess for long periods, symptoms of auto-intoxication appear, especially if the liver or kidneys are inefficient.

In dyschezia the retention of solid faeces in the rectum, which is normally empty, may give rise to a number of reflex symptoms, such as headache and general malaise, which disappear immediately the bowels are opened. The instantaneous relief proves that these symptoms cannot be due to auto-intoxication. Moreover, experimental distension of the rectum with a large plug of wool produced identical symptoms. The pressure on the surrounding parts by the retained faeces also gives rise to perineal discomfort, and occasionally to pain which may spread to the sacral region and even down the back of the legs. Pressure on the haemorrhoidal veins may give rise to piles, and the passage of large hard scybala through the anal canal may produce anal ulcers.

*Reflex
symptoms in
dyschezia*

When the pelvic colon as well as the rectum is filled with hard scybala the passage of gas from the proximal colon may be prevented. This leads to distension and discomfort in the lower abdomen. The obstruction caused by impacted faeces may also give rise to severe colic owing to the reflex peristalsis and spastic contraction which it calls forth.

*Distension
in lower
abdomen*

The irritation of the mucous membrane of the pelvic colon and rectum when hard faeces are retained for long periods produces an excessive secretion of mucus. This is the normal response of the mucous membrane to mechanical irritation, but if excessive and long-continued a true catarrh of the mucous membrane may finally develop.

*Irritation of
mucous
membrane*

5.—DIAGNOSIS

Many people complain of constipation without adequate cause. Before a self-made diagnosis of constipation can be accepted, it is necessary to ascertain what happens to the patient under natural conditions, for the majority consult a doctor only after they have begun to treat themselves with aperients. They regard themselves as constipated because they take aperients, though frequently their bowels would act sufficiently without any artificial aid. The patient should therefore be instructed to take no aperient and to make an effort to open his bowels every morning after breakfast, even if he feels no inclination to do so. If he succeeds, it is clear that he was not constipated at all and that both the local and general symptoms of which he complained are the result of purgation. If, on the other hand, the bowels are not opened, the abdomen and rectum should be re-examined; an empty colon and a full rectum indicate the presence of uncomplicated dyschezia; an empty rectum indicates the presence of inability of the colon to empty its contents into the rectum, and an attempt should be

*Method of
examination*

Radiological examination

made to ascertain where the retained faeces are collected. If hard scybala can be felt in the pelvic colon through the anterior rectal wall, pelvic-colon dyschezia is present. If the caecum and ascending colon are distended with soft faeces and little or no accumulation is felt elsewhere, the comparatively rare condition of ascending-colon constipation is probably present. In severe cases the diagnosis should be confirmed and amplified by an X-ray examination carried out whilst the patient is taking no aperient, but the colon should be completely evacuated by an enema the evening before the opaque meal is taken.

6.—TREATMENT

Hygiene of the bowels

In a large proportion of cases constipation can be cured by restoring to activity the defaecation reflex, which has been allowed to become inefficient by neglect and by constant interference with its normal performance by the habitual use of aperients. A simple explanation of the physiology of defaecation and encouragement are often all that is required, but it may be necessary to reduce the work the muscles of defaecation have to perform by giving liquid paraffin or an unabsorbable vegetable mucilage to increase the bulk and soften the faeces, together with a diet containing plenty of fruit and green vegetables.

The vast army of hypochondriacs, who are never happy unless their stools conform to an ideal which they have invented for themselves, can be cured only by making them realize that faeces have no standard size, shape, consistence, or colour; they may then be ready to follow the example of the dog rather than that of the cat—and never look behind them.

Diet

A good mixed diet contains everything that is necessary to promote the normal activity of the bowels. When there is a tendency to constipation, the patient should be instructed to take some kind of fruit, whether fresh or preserved, raw or cooked, with each meal, and green vegetables or salad with both lunch and dinner. Stewed prunes for breakfast are particularly useful. Proprietary foods containing large quantities of roughage should be avoided, as their coarse ingredients are a common cause of gastritis and they have no advantage over fruit or vegetables.

Drugs

All cases of constipation, and especially those in which the faeces are deficient in bulk, benefit from the use of substances which pass through the alimentary tract without being absorbed and which by their bulk and consistence render the stools sufficiently large and soft to be easily propelled along the colon and expelled from the rectum. It is essential, however, that they should be of an unirritating character, and for that reason psyllium seeds should never be used. Liquid paraffin and certain vegetable mucilages fulfil the required conditions, but liquid paraffin has the disadvantages of sometimes causing flatulence and sometimes

leaking from the anus. Liquid paraffin can be given in doses varying from one teaspoonful to one tablespoonful after breakfast and at night. Among the vegetable mucilages which may be prescribed are agar-agar, and the proprietary preparations i-so-gel, coreine, and normacol. The usual dose is a teaspoonful once or twice a day. It is important to avoid the numerous preparations in which the beneficial effects of liquid paraffin and vegetable mucilages are more than outweighed by the irritant action of phenolphthalein and other purgatives which have been added to them.

A small proportion of patients with constipation cannot be cured *Aperients* without aperients. The most generally useful aperient is senna, which has the advantage of increasing the activity of the colon without affecting the small intestine. The requisite number of pods should be infused with cold water for three hours. The infusion should be drunk on going to bed, and if experience shows that it causes any discomfort, between 5 and 15 minims of tincture of belladonna should be added to it. The number of pods should be varied from day to day till the proper dose is found—one which produces a single formed stool after breakfast. An average initial dose is six pods. An attempt should be made from time to time to reduce the number by one at a time. By this means it is sometimes possible to re-educate the colon to act without artificial help; a dose of ten or more pods may in this way be gradually reduced to zero.

For patients with disorders of the gall-bladder, Epsom salts taken *Promotion of biliary drainage* fasting in the morning in an amount insufficient to cause looseness is the best aperient, for it also promotes biliary drainage by causing the bile-ducts to contract and Oddi's sphincter to relax. Magnesium hydroxide mixture, B.P., being an alkali, is a useful aperient for constipated patients who have or have had a gastric or duodenal ulcer.

The majority of cases of dyschezia can be cured by simple re-education *Enemas and suppositories* of the defaecation reflex, but it is sometimes necessary to begin the treatment by giving graduated enemas. When the patient is quite unable to evacuate his rectum although it is loaded with faeces, an enema of one fluid ounce of glycerin should be given in the morning just after an unsuccessful effort has been made. The strength of the enemas should be gradually reduced by replacing one fluid drachm of glycerin by water every other day until only water is used. As a rule the normal defaecation reflex and with it the tone and contractile power of the rectum slowly return. When dyschezia is due to inability of the pelvic colon to empty its contents into the rectum, six fluid ounces of liquid paraffin should be injected on going to bed and retained during the night; the bowels are generally opened without difficulty in the morning.

When the sphincter ani is in a condition of spasm as a result of *Diathermy* inflamed haemorrhoids or an anal ulcer, or when the anal canal is congenitally narrow or a stricture has followed an operation for haemorrhoids, complete relief can be obtained by dilating the sphincter by means of diathermy applied locally through a conical electrode.

Exercise

Regular exercise in the open air helps to keep the bowels active and should be ordered especially for individuals who follow a sedentary occupation. In people who are busy all day, five minutes' walk just before or after breakfast is often enough to call forth a defaecation reflex which would otherwise not occur. Special exercises for the abdominal muscles and the muscles of the pelvic floor are of great value for patients in whom dyschezia is in part due to weakness of the voluntary muscles of defaecation.

Massage

Massage is of use only in cases in which there is well-marked stasis in the proximal part of the colon: if possible, the first treatment should be given during an X-ray examination, so that the masseur can see the exact position of the colon and can find which manipulations have most effect upon it.

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CONSTITUTION AND HEREDITY

See HEREDITY AND CONSTITUTION

CONTRACEPTION

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Reference may also be made to the following title.

STERILIZATION

1.—DEFINITION AND CLASSIFICATION

258.] The term contraception or birth control is applied to expedients which aim at preventing the fertilization of the ovum by the spermatozoon. The following are the most commonly employed methods:

- (1) A rubber sheath or 'condom' covers the penis and thus prevents the deposition of semen in the vagina.
- (2) The penis is withdrawn prior to emission—a practice variously called *coitus interruptus*, 'withdrawal', or 'being careful'.
- (3) Sperms deposited in the vagina are destroyed by chemical substances in the form of suppositories or jellies.
- (4) Semen is removed from the vagina after ejaculation by means of a plain water or a medicated douche.
- (5) Coitus may take place when it is believed that there is no ovum available for fertilization—i.e. in the so-called 'safe period'.
- (6) A rubber cap covers the cervix with the object of preventing spermatozoa from passing up the cervical canal.

2.—METHODS OF CONTRACEPTION

Before discussing the relative merits or special indications for these methods, it is desirable to describe them separately in detail.

(1)—The Sheath

With the exception of *coitus interruptus*, this is probably the most generally used of all contraceptive expedients, and experience shows that, when properly used, it is probably the safest of all.

*Types of
sheaths*

The term 'sheath' may be taken to include rubber washable sheaths, fine animal skins, and thin rubber condoms (or 'French letters'). Condoms are the type generally preferred, but since their price ranges from 6d. upwards (this is the English price-range, it is equally high abroad), and they can only be employed once, their cost is often prohibitive. The thicker washable rubber sheaths cost initially about the same, but may be used from fifty to a hundred times.

It is generally believed that sheaths and condoms are unsuitable for the tropics. Actually they can be specially packed for use abroad, posted to any place in the world, and will retain their elasticity in the hottest climates for at least a few weeks.

*Precautions
in use of
sheaths*

The disadvantages of the appliance are mainly aesthetic; many men and women dislike it and feel that it deprives the sexual act of much of its essential significance. When it is recommended, the following points should be impressed on the user.

*Where to
purchase*

In the first place, it is, for several reasons, inadvisable to buy sheaths from retail chemists. Fantastic charges are often made; the stock may be old and the rubber inelastic or friable; inferior grades of sheaths

are manufactured, which have not been properly tested for imperfections or minute holes in the rubber, and yet are sometimes sold, at enormous profits to the middleman, as the best obtainable. The purchaser should be advised to apply to a reputable manufacturer for his catalogue, and order direct from him. If security against pregnancy is a very important consideration, a fairly thick sheath should be used, since those made of very thin rubber may tear even if the material is of the best.

Secondly, the sheath should be used in conjunction with a lubricant. *Use of lubricant* Complaints from women that the sheath is disagreeable or hurts are not infrequently traceable to the fact that intromission is less easy to accomplish when a sheath is used than when it is not. This is especially noticeable if the secretions from the cervix and from Bartholin's glands are defective. The inconvenience can be completely overcome if, after the sheath is put on, the end is smeared with a non-greasy lubricant such as compound tragacanth paste B.P.C. or K.Y. Jelly. It was shown in a statistical inquiry that the sheath in conjunction with a spermicidal ointment or jelly was more reliable than any other combination of contraceptive devices, unwanted pregnancies occurring in only 2 per cent of couples who used it. Hence it seems reasonable to advise a lubricant which contains a spermicide; a greasy lubricant will rot the rubber and so must not be chosen when a sheath is to be washed and used again.

Thirdly, a sheath with a teat end is sometimes recommended, for the following reason. *Teat-ended sheaths* If the sheath fits tightly over the glans and body of the penis, the rubber covering the glans will be stretched when emission takes place. When detumescence occurs, the semen may then be forced backwards to the base of the sheath, and enough may escape on to the vulva to effect fertilization. This cannot happen if the sheath has a teat end which is collapsed (i.e. not distended with air) when the sheath is adjusted. Most sheaths are manufactured in such a way that the rubber is thickest at the end and thinnest at the base. Tears and ruptures usually occur towards the base, very rarely at the end.

Fourthly, careful questioning of those who claim that the use of a sheath has resulted in an unwanted pregnancy proves that some men are in the habit of putting it on towards the end of coitus, just previous to ejaculation. It has been found by Abraham Stone that the pre-ejaculatory secretion of the urethra may contain small numbers of spermatozoa. *Spermatozoa in pre-ejaculatory secretion* These might effect fertilization if the coital act were begun without the man wearing a sheath. In these circumstances, the method might be wrongly blamed.

Fifthly, the user should be told to examine the sheath shortly after ejaculation and to test it for holes either by blowing it up with air or distending it with water. If it is found not to be intact, the woman should, without delay, douche with warm soapy water. *Examination of sheaths*

Sixthly, if the sheath is to be used again, it should be washed, dried, *Method of storing* and powdered after use and put away folded, not rolled up. The

process of rolling a sheath imposes an unequal strain on the rubber, that portion on the outside being stretched and that on the inside compressed. Hence the segmented appearance of sheaths that are long kept rolled up. If properly cared for, a good sheath continues to be serviceable for a long time. The 'condom' type is generally supplied rolled like a finger stall, and is not intended for repeated use.

*Simultaneous
use of
spermicide*

When the highest degree of safety is desired, it is advisable also that the wife should insert a soluble suppository before coitus; this can be done very easily while the husband pauses to adjust the sheath. An alternative for experienced couples is to keep at hand some quickly working spermicide, in case there should ever be a breakage of the sheath. This accident is generally evident on withdrawal, and the woman should either douche promptly or insert a spermicidal jelly. Should neither of these courses be possible, the vagina can be rapidly cleansed by two fingers covered with soap.

*Effect of
precautions
on
failure-rate*

If these precautions are observed, the chances of conception occurring are, for practical purposes, negligible. It may be remarked that in the series of cases referred to above as showing a failure-rate of 2 per cent, it was impossible to ascertain whether or not these precautions had been fully observed. Since they are by no means universally recognized, it is highly probable that in some of the cases they were not. But, as stated above, many couples dislike the sheath on aesthetic grounds. The user should therefore be told that if such objections are strongly felt, alternative, though probably not quite as reliable, methods may be substituted.

*Further
indications
and contra-
indications*

The following additional comments may be thought relevant. In cases of waning potency, the process of adjusting the sheath may extinguish desire and cause detumescence; or it may be found impossible to reach an orgasm on account of the diminished cutaneous sensation which the wearing of a sheath entails. Conversely, in young and over-excitible men, the wearing of a sheath may, for the above reason, enable the coital act to be prolonged in such a way that the orgasms of the two partners may be more nearly synchronized than is otherwise possible. Lastly, it is obvious that if there is thought to be a risk of venereal disease being conveyed or contracted, it is the only permissible method.

(2)—Coitus Interruptus

This is undoubtedly the most widely used birth-control method in the world, and probably the oldest. Its efficiency must have been questioned since time immemorial, but its serious disrepute is but a matter of a few years' standing.

The practice of withdrawal is almost universally known, it costs nothing, and requires no preparation. It is not therefore surprising to find that the majority of couples have, at some time or other, attempted it. Although families of large size are frequently found in which all the children have been conceived in spite of this method, the parents

are probably correct in their belief that their care has gone some way towards spacing their children, and that perhaps more pregnancies might have occurred without it.

From the point of view of safety the method must always be considered hazardous, on account of the frequent presence of a few spermatozoa in the pre-ejaculatory fluid. *Unreliability of coitus interruptus*

The view is now widely held that any factor which interferes with the satisfactory completion of the sexual act is liable, in some persons, to induce or accentuate the condition known as anxiety neurosis. Important among the factors which cause anxiety neurosis is the practice of *coitus interruptus*. It must be considered in its effect on either partner.

As regards the male, it has been suggested that direct injuries to the genital system may be caused, such as enlargement of the prostate, or congestion of the seminal vesicles. Opinion in general is against this being so, and it is probable that the trauma should be looked for in the nervous system and not in the genital tract. *Effects on male*

Withdrawal before ejaculation generally causes some deprivation of pleasure to the man, as well as a strain (very severe for some) of keeping control throughout a process in which its maintenance may require an overwhelming effort. Some men can apply such restraint even for a period of years without apparently suffering in any way. Others may come to experience anxiety in some form.

Among women there are some on whom withdrawal may have little or no ill-effect, as, for instance, women who can reach their orgasm either before or in spite of withdrawal, or those who so rely on their partners that they need not share in the effort of restraint, or those who are equally frigid whether coitus is interrupted or not. *Effects on the female*

An additional restraint should be considered. There is a very common but entirely erroneous belief that if the woman does not experience an orgasm the likelihood of pregnancy will be much diminished. It is possible for women to exert so much mental control that the orgasm is entirely inhibited. This practice, called 'holding back', is so taken for granted by many women that, unless the practitioner remembers to speak of it specifically, he may recommend a change from an unsuitable contraceptive method to a better one and yet leave the woman practising her own restraint, believing it to be an additional safeguard. It can be said with certainty that this practice is harmful to a woman. The very fact that she has to 'hold back' proves that she is capable of and desires an orgasm. The repeated frustration will lead in many instances to frigidity, and an imposed frigidity of this type is always detrimental to the emotional and physical health. *'Holding back'*

(3)—Spermicidal Preparations

These take the form of jellies, suppositories, and foaming tablets. In recent years the market has been flooded with an enormous number of these products, but inquiry has revealed that few have been given clinical

trial or been subjected to adequate laboratory tests, and it is therefore extremely difficult to form an opinion as to which of them, if any, can be safely recommended.

Preparations of this sort should satisfy three requirements: they should be reliable in the absence of occlusive appliances, harmless, and aesthetically unobjectionable. Of these three characteristics, the last is the only one which can be determined with any facility. It is easy to find out whether a preparation does or does not smell, smart, stain, or leave disagreeable after-effects. It is very difficult to form an opinion on the question of reliability. All the preparations which hitherto have been given adequate trial have been found to be unreliable in a varying proportion of cases.

(a) Suppositories and Tablets

Suppositories and tablets

Spermicides in the form of suppositories (sometimes called soluble pessaries) or tablets are inserted deeply into the vagina before intercourse and usually an interval of ten minutes is required before their optimum effect is obtained. The woman should be recumbent after their insertion, to prevent any leakage of the preparation from the vagina.

Contraceptive suppositories can be classified into three types: (1) those with a cocoa butter base, (2) those with a base of gelatin and glycerin, and (3) dry 'effervescent' tablets. The two former have the disadvantage that, being designed to melt at the body temperature, they cannot be used where climatic conditions rise above that heat.

Quinine as a contraceptive

Cocoa Butter Type. Until recently the most popular type of soluble suppository consisted of a cone of cocoa butter containing about 2 grains of a quinine salt. Such a suppository when in use melts, the cocoa butter base making a thin greasy film over the vagina and penis. Very occasionally, one or other of the partners will react to quinine, either generally or with local irritation or a rash. Recent investigations have shown that the efficiency of the preparations depends less on their quinine content than on the greasiness of the base, which has a mechanically inhibiting effect upon the spermatozoa.

Soluble suppositories are fairly satisfactory for couples who are prepared to trust to a chemical method alone. The expectation of failure of ordinary quinine suppositories when used over a period of several years was estimated in one inquiry at about 46 per cent. They are not very expensive, are equally effective whether the vaginal passage is dry or lubricated, and can be stored well in temperate climates though not suited for the tropics. They cannot be used with an occlusive cap or a washable sheath, because the rubber perishes very quickly when in contact with any greasy preparation.

Glycerin and Gelatin Type. Glycerin soluble pessaries are now being prescribed at birth control clinics for use either with a sheath or an occlusive cap. They do not injure rubber and they melt whether vaginal secretion is present or not. They have no odour and do not irritate;

but some women dislike their slight stickiness; in some cases, too, they appear to be hygroscopic causing excessive vaginal moisture.

Tablets. These embody the spermicidal substance in a base consisting of compounds which, in the presence of moisture, interact with the production of a more or less dense foam. The function of this foam is to serve as a vehicle for the spermicide and at the same time act as a mechanical barrier across the vaginal vault and external os. The chief disadvantage of effervescent tablets is that their efficiency depends upon a very variable factor, namely, the amount of vaginal moisture. In many cases they fail to dissolve and may be recovered, even after several hours, practically unaltered from the vagina. *Production of foam*

(b) *Jellies*

Spermicidal jellies in collapsible tube containers are injected into the vagina through a suitable nozzle. Though more expensive than suppositories and a little more difficult to apply, they have the advantage of being introduced into the vagina in a dissolved and active condition, and in a more suitable vehicle than any used in the preparation of suppositories.

Jellies are of two main types, simple and foaming. In the former the spermicidal substance is incorporated in a water-soluble base, e.g. glycerin of starch; in the latter an acid and alkaline substance, in separate compartments of a collapsible tube, are mixed together when squeezed through the nozzle and produce a fine foam of jelly and carbon dioxide. This foam and the spermicides incorporated in the jelly together form a contraceptive with a mechanical and chemical action. *Two types of jellies*

Unfortunately the introduction of jellies into the vagina is by no means fool-proof. In most of the available preparations the nozzle is too pointed for safe insertion and the woman should be instructed to cover the tip with her index finger and insert it thus shielded into the vagina—a manoeuvre which is easiest in the recumbent position. She can then withdraw the finger and express the jelly from the tube with one or both hands. *Advantages and disadvantages of jellies*

Contraceptive jellies, simple or foaming, are suitable for any climate, and, unlike 'effervescing' tablets, they do not depend for their efficacy on the conditions of the vaginal secretion. Their serious drawbacks are the cost, which is considerable at present, and the rather cumbersome and ostentatious method of use. For this reason jellies are not widely employed, but are largely reserved for cases in which exceptional security is required from a chemical contraceptive alone.

(c) *Summary*

Of spermicidal preparations in general, it may be said that they are simple to use and give a moderate degree of security. Some women who have used these devices throughout their married life have succeeded in spacing their pregnancies at will. Others using the same

devices have become pregnant on the first occasion. Between these extremes can be found every degree of failure and success.

It must be emphasized that although the jellies are more effective than suppositories or tablets, they may fail if the bulk of the semen is deposited against the external os. If, however, the surface is covered by an occlusive cap, the presence of an efficient spermicide in the vagina will be of the greatest value. There is still need for a chemical contraceptive consisting of an immediately spermicidal but harmless substance in a vehicle which will spread rapidly and form a complete mechanical barrier across the cervix. Research designed to produce such a contraceptive is being carried out under the auspices of the Birth Control Investigation Committee, London.

(4)—The Post-Coital Douche

This method is fairly widely practised, but has serious disadvantages. It is most uncertain—the failure-rate in one investigation amounted to 73 per cent; it necessitates the woman getting up immediately after coitus; and it calls for facilities, e.g. privacy, which are not available in many poor households. Probably the chief reason for its fallibility is that, if semen is deposited against the external os, spermatozoa will pass within a minute or so into the cervical canal and become inaccessible to the douching solution.

The advantage of the douche is that it is cheap. Once the syringe has been obtained, the method costs nothing, but unfortunately it is those who can afford only a douche who have so few of the toilet facilities which its use demands.

Technique of douching

If the post-coital douche is recommended it is important to explain its technique fully. The solution must distend the vaginal walls, and thus obliterate the rugae where the sperms would otherwise be protected. Sufficient pressure to do this can be maintained only by closing the vaginal orifice around the douche nozzle, either by pressing it tightly round with the fingers or, in the case of the bulb or 'whirling spray' syringe, by pressing the conical shaped plug against the vaginal orifice.

Excessive tension must not be employed, since any pressure above 200 mm. of mercury may force the solution into the uterus. With the ordinary douche-can this may be avoided by limiting the height of the can to not more than two feet above the nozzle; when the vagina is full the fluid may be released and the passage again flushed out. With the whirling spray syringe the bulb must be pressed only between the thumb and first finger, which are insufficiently strong to exert excessive pressure. When this appliance is used the solution should be returned several times from the bulb to the vagina until the semen is thoroughly mixed with the spermicidal solution. The syringe should be cleansed thoroughly after use.

Medicated douches

Plain water is spermicidal, but usually a spermicidal chemical is added to the douche. Among simple household substances that may be recommended are vinegar (a tablespoonful to the pint of warm water),

or soap (e.g. a lather made by adding a tablespoonful of lux to a pint of water). Both these materials are accessible, cheap, and probably more effective than the commonly used lysol and potassium permanganate. Occasionally a soap solution will cause smarting in the vagina; in such cases vinegar or plain water should be used instead, or the vagina should be given a final rinsing with plain water.

(5)—The 'Safe Period'

The utilization of the so-called 'safe period' as a contraceptive method is permitted by the Roman Catholic Church. For people who hold moral objections to using chemical or mechanical contraceptives or *coitus interruptus*, this may prove the only feasible method. An increasing volume of literature, emanating for the most part from Catholic doctors and priests, has recently appeared upon the subject, and various methods have been proposed for calculating the precise period during which coitus is sterile. The evidence is now overwhelming that ovulation takes place, not at the time of menstruation as was formerly supposed, but in the mid-menstrual week. There are good reasons for supposing that during the pre-menstrual week (i.e. the seven days elapsing before the onset of the menses) conception is less likely to take place than at other times in the cycle. It is believed that the human ovum can only remain in a fit condition for fertilization for a matter of about twenty-four hours, and that spermatozoa can retain their activity in the uterus and Fallopian tubes for not more than a few days. It is as yet uncertain whether, in the human female, coitus can act as a stimulus to ovulation, as undoubtedly happens in such animals as the rabbit and the ferret, but recent work seems to oppose this hypothesis.

*Basis of
'safe-period'
method*

Those who recommend the utilization of the 'safe period' for contraceptive purposes stress the fact that it can only be regarded as reliable in the case of women whose menstrual cycle is uniform and regular. An abnormal prolongation of the cycle might be due to one or two causes, either a lengthening of the period before ovulation or that occurring after it. A lengthening of the post-ovulation period would have no effect upon the infertility of the pre-menstrual week. A prolongation of the pre-menstrual period, however, might result in ovulation being postponed to a period which was regarded as 'safe'. It is as yet too soon to estimate how reliable this method is, though data on a considerable scale are being accumulated in various Roman Catholic countries. Persons wishing to use it may be advised by their practitioner to read *The Sterile Period in Family Life* (see references on p. 404) in which the methods of calculating the dates of the high and low risk periods are clearly set out.

*Limitations
of the
method*

(6)—The Occlusive Cap

The contraceptive method most commonly taught at Birth Control Clinics involves the use of the occlusive cap, the only harmless contra-

ceptive device which gives a degree of safety comparable with that of a sheath.

*Three types
of cap*

Three types of cap are commonly used: the Dutch, Dumas, and cervical (see Figs. 49 and 53). The average retail prices in England are, Dutch 5s., Dumas 7s. 6d., and cervical 3s. 6d. These caps may last anything from nine months to three or four years, provided that the climate is temperate and that soft paraffin or other greasy ointments are not applied to the rubber. In tropical climates, caps may need renewal every three to six months, and should be stored powdered in air-tight tins.

(a) The Dutch Cap

This is the best choice for most women. It consists of a circular watch-spring covered by rubber which forms the rim of the cap, and across it is stretched a soft dome of rubber, the diaphragm. Eighteen

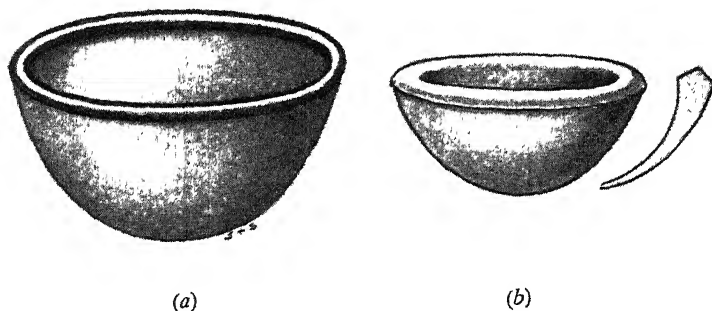


FIG. 49.—(a) Dutch cap; (b) Dumas cap

sizes are made, increasing in diameter by increments of $2\frac{1}{2}$ mm.; the diameter of the smallest cap is 45 mm. and of the largest 90 mm.

*Position of
Dutch cap
in use*

The Dutch cap is fitted obliquely across the vaginal passage, in the same way as a circular ring used for prolapse. The upper and posterior part of the rim lies in the posterior fornix, and the lower and anterior part lies behind and above the back of the pubic bone, within an inch or two of the vaginal orifice. Thus the cervix and most of the anterior vaginal wall are covered by the diaphragm of soft rubber. Usually the cap is inserted with the dome uppermost towards the cervix, this position slightly facilitating its removal; there is no objection to inserting the cap with the concavity towards the cervix.

The size of the cap depends on the length of the vagina and is generally greater in tall women. An average fitting for multiparous women ranges from about 70 to 80 millimetres. In cases of retroversion the distance from the pubic bone to the posterior fornix is shorter, and even a multiparous woman might wear a cap between 50 and 60 mm. in size.

It is customary to fit the largest size which is comfortable to the

woman (see Fig. 50 (a) and (b)). With practice this measurement can be roughly estimated at the first fitting. The exact size is best ascertained at the second attendance when the woman will have less tendency to vaginismus.

The suitability of a Dutch cap for any woman depends upon the shape of the vaginal cavity and the support afforded by the vaginal walls. In many women the vagina has a small concavity above the pubic bone into which the front rim of the cap will fit. This concavity is not likely to be present if the woman has a tendency to cystocele, and in some women the anterior vaginal wall slopes in such a way that there is no support for the cap. In general, if the uterus is retroverted a Dutch

*Suitability of
Dutch cap*

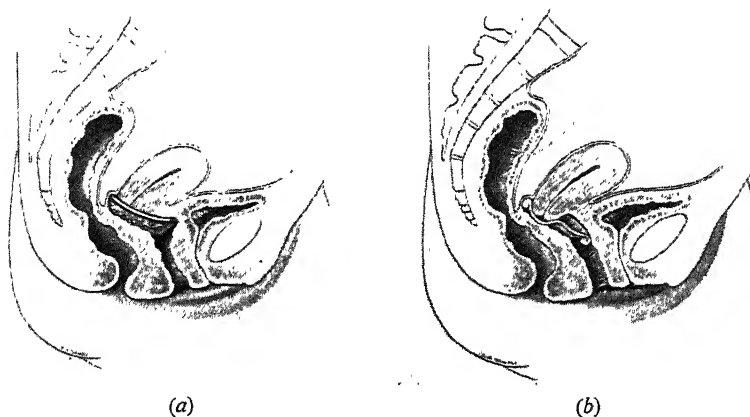


FIG. 50.—Dutch cap in position: (a) perfectly fitting; (b) adequately fitting

cap can easily be worn, the front rim finding its place rather high up against the anterior vaginal wall.

In cases in which the anterior vaginal wall offers inadequate support for the cap the examining finger will find that the rim drops in front. This may not be uncomfortable for the woman, but it is important to decide whether it can drop so much that the penis might enter between the anterior vaginal wall in front and the cap behind. If there is this risk the cap should be discarded in favour of another type.

Occasionally a large cap with a stiff rim will cause discomfort, and some women can recognize an interference with muscular contraction during coitus. Rarely also, discomfort is caused by a Dutch cap when the woman is in the upright position. The sensation, which is described as a vague aching or dragging pain, is caused by the pressure of the cap on prolapsed or tender ovaries and is relieved at once by recumbency. In such cases, if no alternative cap can be fitted, the patient should be instructed to douche and remove the cap directly she rises.

*Associated
discomforts*

The accurate fit of Dutch caps depends on the tone of the vaginal musculature, a factor which varies slightly from time to time. After a

*Need for
refitting*

debilitating illness or after childbirth the cap should be refitted, and during the early months of marriage it may require changing two or three times. If a patient is fitted at the time of marriage it is advisable that she should return in three months and then again in six months, after which it is probable, though not certain, that the fitting will be suitable until after childbirth.

*Advantages
of Dutch cap*

The points in favour of the Dutch cap are (1) that for most women it is the easiest cap to use, being the quickest to adjust and extract;

*Disadvantages
of Dutch cap*

during coitus; and (3) that it allows free drainage from the cervix. Its disadvantages are (1) that in some women it may cause discomfort if worn in the daytime; and (2) that it may occasionally become dislodged

by defaecation and very occasionally may fit imperfectly when resting against a loaded rectum.

Insertion. The patient should be instructed to hold the dome of the cap in the hollow of her right hand. The rim is squeezed together between the thumb and first finger and supported thus against the vaginal orifice, while the left hand pushes the cap backwards along the posterior vaginal wall into the posterior fornix. The last part of the cap to disappear must be pushed well up behind the pubic bone.

In a fairly large proportion of cases the cervix lies in such a position

that the cap may be pushed into the anterior fornix instead of the posterior one. To avoid this, the woman should remember to aim the cap *backwards* towards the rectum, not upwards towards the abdomen. It is most important that the patient should understand the difference between these two positions. It is best that she should check the position of the cap by feeling for the cervix with her index or second finger, and thus make certain that it is covered by the soft rubber of the dome. As it is not possible for all women to reach the cervix, the alternative guide is the position of the anterior rim of the cap. If the cap is correctly placed, the rim should be well up behind the pubes and comfortable if pushed on by the index finger. If incorrect, the anterior rim will be lower down, towards the entrance of the vagina, and is usually very uncomfortable when pressed on (see Fig. 51).

*Method of
removal*

The extraction of a Dutch cap is generally easy. The index finger should hook down the anterior rim, pressing it against the back of the pubic bone. An alternative method is to extract the anterior rim by gripping it between the tips of the index and second fingers. The rim

*Instruc-
tions to
patient*

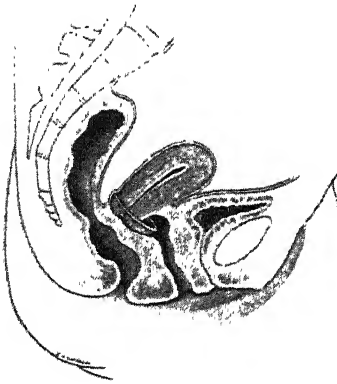


Fig. 51.—Dutch cap, too small and incorrectly fitting

may be found to be slightly out of the circle after its withdrawal. It should be pressed back into a circle after it has been washed and dried.

(b) *The Dumas Cap*

This cap (see Fig. 49) is intended to fit into the vault of the vagina, reaching from the anterior to the posterior fornix, and covers the cervix, which, in cases for which the Dumas cap is suitable (see below), is small or shallow. It is considerably smaller than the Dutch cap and is made of thick, unyielding rubber at the edges, but thinner rubber in the centre of the dome. Three sizes are used, small, medium, and large.

Since the dome of the cap is stiff, it is supported from below by the bulging in of the vaginal walls, and in some instances is said to adhere to the vaginal vault by suction (see Fig. 52).

In general, the Dumas cap is unsuitable in cases in which the cervix is large or pointed, as the dome is not deep enough to contain any but a flattish cervix. It should not be worn over a cervix which is pointing backwards or is even at right angles to the axis of the vagina, for in these instances it is liable to become dislodged by the penis. The cases for which it is best adapted are those of prolapse with cystocele, rectocele, or both. It very seldom causes discomfort to the woman, but occasionally the stiffness of the dome causes complaint from the husband. Its chief disadvantages are that it is often difficult to extract, and that its fitting against the vaginal walls is generally less secure than that of the Dutch cap.

Insertion. The woman is instructed to squeeze the sides of the cap together with the hollow facing upwards, and to push it thus into the vaginal orifice. The anterior part of the cap is then pressed upwards until it moves into the anterior fornix, the back part automatically passing over the cervix into the posterior fornix. It is necessary that the patient should feel round the vault of the vagina, to make sure that the cervix is not uncovered.

Extraction of this cap is best effected in the kneeling position, by hooking down the left posterior quadrant with the right index finger. Once the cap is dislodged, it can be pulled out quite easily.

*Position of
Dumas cap
in use*

Indications

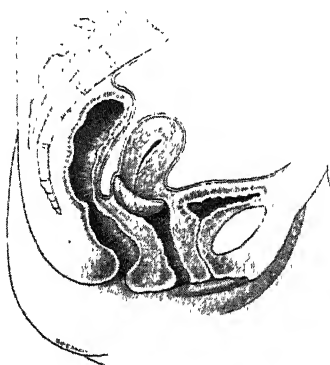


FIG. 52.—Dumas cap in position

Instructions

*Method of
removal*

(c) The Cervical Cap

This cap (see Fig. 53) is designed to fit on to the cervix itself, and is independent of support from the vaginal walls. It is supplied in five sizes—0, 0½, 1, 2, and 3. A small tag is sometimes attached to facilitate

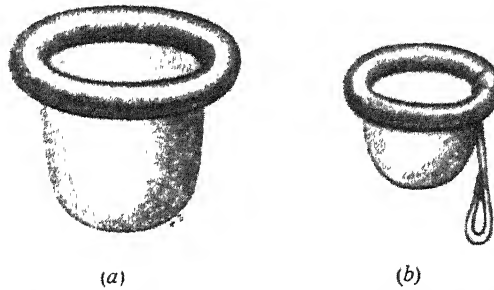


FIG. 53.—Cervical cap: (a) without tag; (b) with tag

extraction, but is in most cases unnecessary. Since the position of the cervical cap does not depend on the vaginal musculature, there is little likelihood that a refitting will become necessary until after childbirth.

Indications

This type of occlusive cap should be prescribed only in cases in which the cervix is well formed and free of any lacerations reaching to the cervical base. Like the Dumas cap, it is contra-indicated if the axis of the cervix is at right angles to the vagina, as it is then liable to be dislodged by the penis. It is most suitable in cases in which the uterus is retroverted and the cervix presents in the axis of the vagina. The cap is not intended to fit the cervix exactly. The dome should extend further than the cervix, this surplus being for the reception of the cervical secretion. The advantages of the cervical cap are (1) that it is the only cap that a

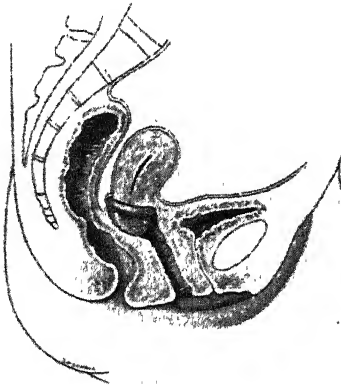


FIG. 54.—Cervical cap in position

Advantages of occlusive cap

Disadvantages of occlusive cap

woman can buy for herself with any chance of getting a correct fit; (2) that it is hardly ever uncomfortable to use; and (3) that it may sometimes be employed in cases of prolapse, in which a supporting ring must habitually be worn. Its disadvantages are (1) that it is very difficult for some women to adjust; (2) that it is liable to be dislodged from the cervix during coitus; and (3) that it retains the cervical secretion which is undesirable if there is a tendency to cervicitis.

Insertion. The cap is held by the patient between two fingers and inserted with the hollow facing upwards. It is then pushed up until it reaches and encloses the cervix, which should always be located bulging through the rubber of the dome (see Fig. 54). *Instructions*

(d) *General Principles*

The principles for using all types of occlusive caps—Dutch, Dumas, or cervical—are the same. *Technique for using occlusive caps*

- (1) In all cases, a non-irritant spermicidal ointment is thickly applied to the cervical surface of the cap. With the cervical and Dumas caps it is usual to fill half the bowl with ointment so that the cervix is sealed in it.
- (2) If possible the cap should be inserted some little time before coitus.
- (3) A chemical suppository or jelly may be added shortly before coitus. Not all clinics prescribe these, but it seems evident that by their use safety must be increased.
- (4) The cap should be left in position for at least ten hours after the last coitus; *or* the woman should douche thoroughly before and after its removal.
- (5) Before being put away the cap should be washed with soap and water, dried, and powdered with French chalk.
- (6) The cap should never be left in position longer than about 18 hours—in cases of erosion it may be advisable to douche and remove the cap shortly after coitus.
- (7) Constipation should be avoided, for a loaded rectum is liable to displace the cap.

The technique of fitting occlusive caps is not difficult, but it requires practical apprenticeship. The practitioner who intends to undertake this work is advised to attend a few sessions at a teaching clinic, for although theoretical knowledge alone may be an adequate guide for some cases, there are many which require real experience for the choice and fitting of the appliances. The equipment required comprises the full range of caps of every type and size; this will cost (in England) roughly £3, and though the original stock of rubber caps will perish in two or three years they can be boiled and used repeatedly for fitting purposes. *Technique of instruction*

The average woman can be fitted with the appliance and taught how to use it in two interviews, the first averaging half to three-quarters of an hour, the second a quarter of an hour; she must be prepared to spend about 8s. 6d. for the outfit and first supply of chemical contraceptives.

The following general instructions conform closely with the procedure adopted in most of the birth control clinics in Great Britain and America.

Having taken the full relevant history, the practitioner makes a thorough pelvic examination, including an examination of the cervix *Procedure of fitting cap*

per speculum if there is any question of a pathological discharge. For the actual fitting, the patient should lie on her back, with the legs slightly flexed. A coverlet should reach well down to the knees so as to minimize any feeling of exposure.

It is not always possible to tell from pelvic examination which type of cap will be suitable. The Dutch cap has the widest application, and it is a good practice to try this first, and if it is found unsuitable to replace it with another type. To facilitate its use the cap should be well covered by a non-greasy lubricant (such as compound tragacanth paste B.P.C. or K.Y. jelly) or dipped into soapy water.

Vaginismus in the course of pelvic examination is so common that the best time to judge if the cap is the correct size is when the patient returns with it *already in place* at the next appointment.

After the fitting, the woman should be instructed to feel the cap *in situ*. When she has located it, she is told to pull it out, and whilst the cap is being washed she is instructed how to feel her own cervix. The woman's best position is stooping or half-kneeling, both for this and for the subsequent placing of the cap herself. The index and second finger will reach well into the vagina and, with the patient bearing down slightly, the cervix will generally be located. She is shown once or twice how to insert the cap, how to make sure it is correctly fitted, and how it feels if the position is incorrect.

*Difficulties
in teaching*

The ease and speed with which the teaching is carried out vary both with the patient and with the experience of the practitioner. Some women have a strong disinclination to examining the shape of the vagina and cervix, and it is only the practitioner's reassurance that this is permissible and necessary that enables them to do so without distress. In practice it is found that only a very small proportion of women are unsuitable for wearing a cap, and that even a smaller proportion are unable to learn the technique of using it.

In the first interview it is generally sufficient for the woman to learn how to insert the cap; she should be told to practise putting it in several times, to wear it one night and return wearing it, but not to trust to it until after her second visit. At this second visit she may be taught all the details of the methods and instructed in any auxiliary methods that may be necessary.

The question is so often asked that it is worth pointing out that no ill results would occur if a menstrual period were to begin when the cap happened to be in position. It should, however, be removed at once when this occurs.

(7)—Sponges and Tampons

Indications

These are sometimes advised when the husband cannot be relied upon to use a sheath (or when this is very unacceptable on aesthetic grounds), and when the woman suffers from some form of displacement which makes the fitting of a cap difficult. Two disadvantages attach to the method. The first is that in so far as it is frequently

*Dis-
advantages*

applicable to multiparous women who have had numerous pregnancies and who have roomy vaginae, the sponge must be somewhat bulky in order that it may properly occlude the cervix and not be pushed into the posterior fornix. The length of the vagina may thus be considerably shortened, a circumstance that can easily be noticed by the husband. In general, any sponge which is large enough not to be dislodged by the coital movement is usually so large that it may cause dyspareunia. The second disadvantage is that unless the sponge is carefully looked after, it may quickly become septic. This happens most easily with marine sponges. Rubber sponges are therefore preferable and they should be boiled for two minutes after use. At first sight, this would appear to be a somewhat formidable complication, especially for very poor women, but we are assured that it is frequently not found to be so. Before insertion the sponge should be soaked in a spermicidal solution such as soapy water, or else in olive oil. The difficulty of keeping a sponge aseptic is obviously overcome if a cotton-wool or gauze tampon is employed which can be thrown away after use. Some women make these for themselves, and find them very satisfactory.

*Method of
use*

(8)—Intra-Uterine Methods

The only intra-uterine method that is still prescribed (though not now very extensively) is the one which involves the use of Gräfenberg's ring. This is a small flexible ring made of closely coiled silver wire, which is passed through the cervical canal into the body of the uterus where, unless untoward symptoms appear, it is allowed to remain for a year or more at a time. According to Gräfenberg, this appliance was successful in preventing pregnancy in 98.4 per cent of 600 cases; but other gynaecologists have not found it as reliable as these figures suggest. According to one authority the ring is expelled in over 10 per cent of cases, sometimes without the patient's knowledge. This means that to the failures which occur when the ring is in its proper place must be added those that result from a false sense of security when the ring has in fact been expelled. Furthermore, there are some women in whom the ring provokes uterine pain, menorrhagia, and metrorrhagia; and even more serious, its presence is held by some observers to have provoked acute pelvic inflammation, salpingitis, endometritis, and parametritis. It is generally admitted that in patients with cervicitis and other forms of genital infection, the ring may convert a latent into a fulminating infection. If pregnancy occurs with the ring in place, it usually proceeds to full term and ends in the normal birth of an undamaged infant; but if abortion occurs the presence of the ring is stated to increase the risk of complications. In view of Carleton's observations on the effects of silver rings on the uterine mucous membrane in monkeys—i.e. atrophy, deposition of silver in the intracellular spaces, and fragmentation of the rings—the possibility that this device may provoke carcinoma cannot be entirely excluded. We do not recommend the use of the Gräfenberg ring.

*Dangers of
Gräfenberg's
ring*

*Stud or
wishbone
pessary*

Another form of intra-uterine appliance which has had a certain vogue in the United States and on the Continent is the stud or wishbone pessary. This appliance is made of a non-corroding metal, usually gold, in a number of shapes of which the most usual resembles a stud with a bifurcating stem and a disc-like lower end. The rami of the stem are pressed together when the appliance is introduced into the cervical canal and when released they separate, acting as a self-retaining device. These appliances are mentioned only to be condemned, for they are thoroughly dangerous. Communicating at one end with the vagina and at the other with the body of the uterus, they form a path along which vaginal organisms can pass into and infect the sterile uterine cavity. Their use has led to septic abortion, pelvic inflammation, and fatal peritonitis. The recorded death-roll is over 100. Women occasionally ask the practitioner to fit them with a gold stud because 'it saves trouble'. In view of the grave risks, such requests should never be complied with.

(9)—Other Methods

Methods involving irradiation of the ovaries and testes to produce temporary sterility, the use of the sex hormones for the same purpose, the injection of semen as an antigen for the purpose of producing spermatoxic antibodies, the application of heat to the testicle to arrest spermatogenesis, these and surgical methods come within the category of sterilization rather than contraception and are discussed in the article under that title.

3.—EFFECTS ON HEALTH AND FERTILITY

*Possible
dangers of
contraception*

The practitioner may be asked for advice upon the suitability and probable efficiency of any of the large number of contraceptive methods in general use. He may be asked if any method could prove injurious either to those who use it or, if pregnancy should inadvertently result, to the child. The risks to health associated with certain methods have been discussed above; to this it may be added that there is as yet no reliable evidence that any of the contraceptive methods which have been recommended are likely to damage a foetus conceived in spite of them. The experience of birth control clinics, moreover, has shown that neither the sheath nor the occlusive cap with a suitable suppository has any deleterious influence on health or fertility. Thus, at some clinics it is the custom to examine the cervix at six-monthly intervals. Among those attending are women who have used occlusive caps for many years, yet the records do not suggest that genital lesions are caused by the contraceptive methods recommended, and erosions are frequently observed to heal spontaneously in women who regularly use a Dutch or Dumas cap.

With regard to fertility, the great majority of women become pregnant

immediately after discontinuing the use of the prescribed contraceptive. *Effects on fertility*
 In 1930, the Walworth and East London Clinics made an analysis of desired pregnancies among their patients. Of 116 women who had been using contraceptives for periods varying from one to five years, 113 became pregnant either immediately or within a few months after they had discontinued their precautions. Nevertheless, it is always advisable to remind patients that the advance of age provides the greatest and most irrevocable menace to their fertility.

In a matter in which personal preferences have such an important part, there can be no 'method of choice'; each case must be taken on its own merits. In all cases, a combination of two methods is safest. The highest degree of security is offered by the sheath combined with a spermicidal suppository. If this is unacceptable, a cap in conjunction with ointment and suppository will give nearly as good protection. This is the technique taught at most birth control clinics. *Value of combination of methods*

Many couples, however, are unwilling to use methods which involve so much trouble, and are prepared to run a slightly greater risk of failure. In such cases a spermicidal suppository or a spermicidal jelly may be advised. These are preferable to the use of a post-coital douche or to the practice of *coitus interruptus*.

If instruction is required at the beginning of marriage, it is usual to advise a sheath and lubricant alone; most spermicidal preparations will sting if the hymen is torn or injured. In selected cases, however, particularly if the husband is unable to use a sheath, some practitioners consider it desirable to dilate the hymen and to teach the woman the use of an occlusive cap before marriage. *Contraception at beginning of marriage*

Women who have recently been delivered, or who are breast-feeding, should always be advised to employ full contraceptive precautions, since lactation offers very poor protection against pregnancy. Pregnancies have, moreover, been known to occur at the menopause, even some months after the cessation of menstruation, and it is advisable for contraceptive measures to be continued for one or two years after the last period. The fear of pregnancy causes much distress to some women at the climacteric—a fact which is worth bearing in mind when dealing with menopausal anxieties. *Contraception during lactation*
Contraception at menopause

For cases in which pregnancy would always be inadvisable, sterilization is a more certain method than contraception of avoiding pregnancy. The indications and methods are fully discussed under the title STERILIZATION. *Sterilization*

4.—EXPECTATION OF SUCCESS

Only the methods taught at the birth control clinics need be considered. The failure-rate for self-prescribed methods, e.g. the post-coital douche, is very high. The sheath gives a considerable expectation of success (see p. 388) and it is suggested that, given an intact sheath *The sheath*

The cap method

and strict adherence to the instructions set out on page 386, the chances of failure are virtually negligible.

The reliability of the cap method has been the subject of several statistical inquiries. An analysis has been made of 6,081 cases in the vast majority of which the Dutch cap had been used over a period from one to seven years. In this series there were 318 failures in which unwanted pregnancies occurred despite the method, i.e. about 1 in 19, or approximately 5 per cent. These failures can be divided into the following categories: unaccountable failures—83 cases; defect failures, in which the cap was found to have developed holes or other defects—55 cases; omission failures, in which some part of the instructions was left out (i.e. no spermicidal ointment was used, the woman did not douche, or allowed herself to get constipated, which all users of the cap are urged to avoid)—111 cases; insufficient information available—69 cases. The figures expressing unaccountable failures (1·4 per cent of the total) have a very important practical implication. Taken in conjunction with a very thorough investigation of 1,294 women which showed an 'unaccountable failure' rate of 16, or 1·24 per cent, they express the fact that, if a woman scrupulously fulfils the instructions attaching to the use of the Dutch cap combination, there will be about one chance in one hundred of its failing in the course of a year, or approximately one chance in 5,000 of its failing at each act of coitus. This estimate is based upon the assumption that the average frequency of coitus is about once a week.

For many proprietary contraceptives such extravagant claims have been made that the National Birth Control Association has arranged to supply practitioners, on request, with a list of the more efficient productions. Inquiries should be addressed to The Secretary, 26 Eccleston Street, London, S.W.1.

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CONVULSIONS IN INFANCY AND CHILDHOOD

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Reference may also be made to the following titles:

DENTITION	PARATHYROID GLANDS,
EPILEPSY	DISEASES OF

1.—DEFINITION

259.] The term convulsion is applied loosely and has, therefore, a varied significance. In its narrowest sense it refers to a series of involuntary, rhythmical muscular contractions.

Such an attack seizing a baby or young child must always be regarded as a symptom and not as a disease; it may be sufficiently severe to demand treatment for its own sake, but the underlying disorder must be identified. From this point of view, convulsions may be regarded as useful manifestations of disease. The patient is too young to voice

his complaint, and may not even be conscious of any distress. Often the first warning that all is not well is that he becomes convulsed. Such a warning should be seriously investigated. When it leads to the discovery of a minor malady, so much the better. If more serious disease is found, valuable time may be gained by making an early diagnosis. Convulsions are distressing but they serve a purpose.

2.—AETIOLOGY

Convulsions arise from many kinds of stimuli acting on the still immature nervous system. It is known that for some years after birth many important tracts of the central nervous system are not fully developed but come into full working order in a regular sequence as the child grows. It is probable that maturity is associated with the growth of the myelin sheaths of the nerve axons concerned. So long as many of the tracts are immature, the baby is liable to sudden unregulated diffusion of nervous energy through its nervous system from comparatively minor stimuli. When such stimuli excite the motor tracts there results a convulsion. It is clear that the amount of undeveloped nervous tissue becomes less and less as the child grows older, and consequently with increasing age a more powerful stimulus is needed to excite a convulsion. Minor disorders that would cause a baby to have a convulsion do not have this effect on a child of five; yet the latter will respond with a convulsion to a stimulus which in an adult would produce only a feeling of discomfort or, at most, a rigor.

Various stimuli may give rise to a convulsion; in the section on treatment it will be necessary to refer to them again at some length, for their removal is an essential part of the treatment of a convulsion. *Causes*

In the nursling a characteristic cause is a digestive upset, such as constipation or a stomach overloaded with indigestible food. During infancy focal infections, such as otitis media, acute tonsillitis, and pyelitis, may be heralded by a convulsion. The onset of an acute infectious disease, with the sudden rise of temperature, may also give rise to this form of disturbance. It is debatable how far chronic digestive disorders in children may be responsible for convulsions. There is a common belief that thread-worms lead to convulsions. Much more certainly a convulsion may be the most dramatic symptom caused by a round-worm. *Digestive upset*

Many diseases of the nervous system which occur in childhood may be ushered in by a convulsion as the first prominent manifestation—especially meningitis of whatever kind; other acute inflammations, such as encephalitis and acute poliomyelitis may have a similar effect. On the other hand convulsions may form a prominent symptom in chronic disorders, such as porencephaly and syphilitic pachymeningitis. In children with a family history of epilepsy, the convulsions may be true epileptic attacks. It is by no means certain that epilepsy is a disease *sui generis*. In some families, however, several generations are afflicted *Diseases of the nervous system*

in a manner which justifies the view that idiopathic epilepsy is a clinical entity.

*Vitamin
deficiency*

During the age period of the deficiency diseases, namely from six to eighteen months, there is always the possibility that a convulsion may be due to deprivation of vitamin D giving rise to tetany (spasmophilia), and in some parts of the world this is the commonest cause of convulsions in early life (see p. 422).

3.—CLINICAL PICTURE

*Initial tonic
phase*

A typical attack has much in common with a major epileptic seizure in an older patient. There is an initial tonic phase in which the body

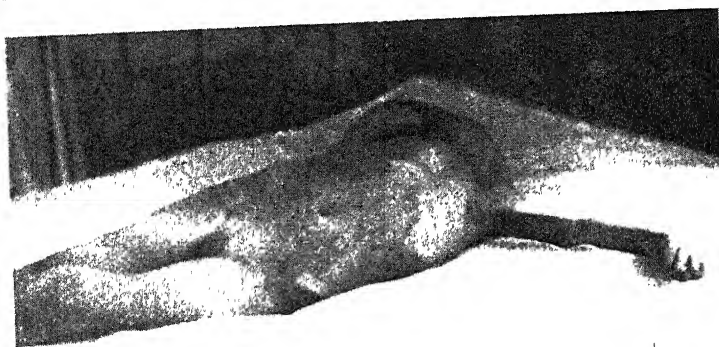


FIG. 55.—Opisthotonos resembling the tonic phase of a convulsion

Clonic phase

and arms and legs are stretched out stiffly, the head sometimes being arched back on the neck in a position of opisthotonos (see Figs. 55 and 56). The duration of this phase is usually a few seconds only. There are no respiratory movements; the patient, who is very pale at the beginning, becomes more and more deeply cyanosed. The tonic passes directly into the second, clonic phase of the attack. In the latter, the arms and legs are violently and rapidly flexed and extended rhythmically. The jaws open and close, and the tongue may be alternately protruded and withdrawn. The eyeballs are usually rolled upwards so that the pupils are hidden behind the upper lids. The muscles around the eye twitch with the rest of the muscles of the body.

During the clonic stage, respiration is re-established and as the first irregular, gasping breaths are taken the patient's cyanosis begins to disappear. The clonic stage lasts for a very variable time; usually it is over in a minute or so, but sometimes twitching movements of the limbs go on for an hour or more.

*Stage of
unconscious-
ness*

During the tonic and clonic stages it is apparent to the parents that the baby is unconscious. As the clonic movements diminish and finally

stop, the infant, who is again very pale, passes into a deep sleep from which he cannot be roused. Later the sleep becomes more natural and the infant either wakes spontaneously or is disturbed by those around him. The duration of the unconsciousness and sleep after an attack varies, and sometimes this stage is missing.

A convulsion does not always present so lengthy or alarming a series of symptoms. Often a mother relates that her baby went stiff and pale, rolled up his eyes, and seemed unconscious, and that in a few seconds consciousness returned. On other occasions some such sequence of events may be associated with a few jerking movements of the limbs. Sometimes the convulsion is confined to one side of the body; in such cases the ultimate limpness occurs on that side.

A doctor rarely sees these minor convulsions as they are over by the



FIG. 56—Opisthotonos

time he is called, and consequently reliance must usually be placed on the parents' account for descriptions of the milder attacks. It is doubtful if the mildest attacks should be regarded as true convulsions. If there is a history of involuntary clonic movements it is reasonable to diagnose a convulsion; when the story is of pallor, stiffness, unconsciousness, and rolling up of the eyes, it is usually right to regard the attack as a convulsion. If the symptoms have been less severe than these, it is not certain that the infant has had a convulsion.

Convulsions are rarely in themselves a danger to life. Unless they recur frequently, they are unlikely even to harm the nervous system.

4.—DIFFERENTIAL DIAGNOSIS

Babies and young children are subject to attacks of other kinds which may be mistaken by the parents for convulsions. Confusion arises most often over breath-holding spells. These characteristically occur when something is being done to an infant of which he violently disapproves, *Diagnosis from breath-holding*

as for instance being given a bath, or being given a bottle instead of a breast feed or, in an older patient, being put to bed; they are an attempt by the baby to get his own way. Even at three months of age typical breath-holding spells may be observed; at this early age it is hardly possible that this form of resistance to authority is deliberately thought out. As the child grows older, it is probable that breath-holding spells are used more rationally. They occur over very much the same age period as convulsions and on that account alone the two may be confused by the parents.

The symptoms of a breath-holding spell further contribute to its similarity to a convulsion. As the procedure to which the baby objects is started, he first cries and then screams and at some point begins to hold his breath. He becomes more and more cyanosed until he is 'black in the face'. Sometimes the cessation of respiration lasts until consciousness is lost. The diagnosis of breath-holding spells can be made from the history that they are brought on by some disliked part of the baby's routine, by the absence of any clonic movements, and by the fact that the baby returns to normal as soon as he gets his own way.

*From
masturbation*

Not uncommonly the effects of infantile masturbation are mistaken for a convulsion. It does not occur to many parents that a child one or two years old, especially if a girl, may be masturbating. On careful questioning it becomes clear that the sequence of events in the so-called convulsion is a series of stereotyped movements, e.g. rocking back and forth on a chair while the infant breathes loudly and becomes red in the face. This is followed by a period of relaxation in which the patient lies back pale and sweating. The minute history of such attacks reveals the diagnosis, and it is only by insisting on a full account of the 'convulsion' that a true opinion can be formed.

*From
syncope*

Syncopal attacks undoubtedly occur in early life although they are not common. Unless an attack is witnessed it may be impossible to distinguish a fainting attack from a convulsion. Even when such an attack is observed it is difficult to say whether the baby has fainted or has had a convulsion in which the motor element is lacking. Syncope must be regarded as rare in the early years although convulsions are not. The vaso-vagal mechanism in a baby is likely to be in good working order; on the other hand, the motor side of his nervous system is much more unstable than in an adult. It follows that if there is any doubt whether an attack is a convulsion or a faint, it is wiser to regard it as a convulsion until this diagnosis can be disproved.

5.—TREATMENT

(1)—Immediate Treatment

Treatment of convulsions must be considered from two points of view: first, immediate measures to stop the convulsion, and second,

removal of the cause. The immediate treatment is partly traditional, *Immediate treatment* because it often happens that an experienced neighbour rather than a doctor can reach the patient before the convulsion stops. Tradition in this case has evolved the simple and sometimes effective remedy of putting the patient in a warm bath and sponging his head with cold water. With this treatment a convulsion arising from one of the less serious causes usually stops. A sceptic might suggest that the convulsion would have stopped in as short a time if nothing at all were done; nevertheless, because it is a simple and harmless treatment it should be given a trial in every case before using more drastic measures.

If the convulsion does not quickly cease with such treatment, it is *Drugs* necessary to use drugs. The most useful drugs are potassium bromide and chloral hydrate. They seem to work better in conjunction than separately, but either may be given alone with a good prospect of success. The dose depends upon the age of the patient. Allowing for this, it is better to give the full dose at once rather than to give a smaller dose with the object of repeating it if it is ineffective. For a baby of three months, chloral hydrate $2\frac{1}{2}$ grains with potassium bromide 5 grains should be given by mouth. For a patient one year old twice that amount can be given, three times as much at two years and four times as much at seven. In many cases it is impossible or unsafe to give drugs by mouth during the course of a convulsion because of the risk that the medicine may be inhaled by the unconscious infant and give rise to an aspiration pneumonia. Even if this disaster is avoided, some of the dose will probably be spilled or spat out and it is then impossible to estimate how much of the medicine has been given. Only when it is certain that the swallowing reflex still exists is it right to give the drugs by mouth.

In all other cases it is wiser to give the drugs *Drugs per rectum* per rectum; this method is more tedious and laborious and results are not so rapidly secured. The doses of chloral hydrate and potassium bromide are half as much again as those for oral use; they should be dissolved in an ounce of water warmed to a little above blood heat. The rectum should be washed out with warm saline before the dose is given; saline is preferable to a soap and water wash-out or a glycerin enema because the subsequent dose is more likely to be retained if the lower bowel has been irritated as little as possible. After the rectum has been emptied the baby should be laid on his back; a well lubricated, small catheter, to which is attached a length of rubber tubing and a glass funnel, should be passed up gently for about three inches above the anus, and the solution of potassium bromide and chloral hydrate should be run in very slowly under gravity, the funnel being held from twelve to eighteen inches above the bed.

It is unfortunate that the more tedious and less effective rectal injection of drugs must so often be used for infants in a convulsion. There is no subcutaneous injection readily available. Opium derivatives are unsuitable; they are so extremely poisonous to babies and young children that it is difficult to find an effective yet harmless dose. The action

of hyoscine is too uncertain in the youngest patients; usually it seems to have no effect at all until a critical dose is reached and above that dose it may cause an alarming collapse.

A somewhat similar criticism might be made of the method of subcutaneous injection of a solution of magnesium sulphate which has sometimes been advocated. Although its use does not seem to be attended with any unpleasant consequences, it is far from certain that it has any effect at all on a convulsion. Intrathecal injection of a solution of magnesium sulphate seems to be equally ineffective.

It will be appreciated therefore that the safest and, in the long run the most effective, drug treatment for a convulsion is the laborious rectal administration of potassium bromide, or of potassium bromide combined with chloral hydrate.

*Treatment
in special
cases*

Convulsions arising from the less serious disorders usually respond to one or other of the measures which have been outlined above. There are some diseases causing convulsions, for instance tuberculous meningitis, which are so serious that no treatment is of any avail. Between these extremes there are occasional cases in which a minor stimulus seems to be applied over a long period; no deep-seated disease of the nervous system can be found, yet the baby goes from one convulsion to another for several hours. In these uncommon cases the simple measures of bath and bromides seem ineffective and it becomes necessary to devise some other form of immediate treatment.

Anaesthesia

In such circumstances general anaesthesia should be considered, but should not be undertaken lightly; the objections to it are obvious. Chloroform is open to so many objections that it is not the anaesthetic of choice. Ethyl chloride or nitrous oxide hardly give anaesthesia of the required duration. Yet ether, the only practical alternative, occasionally gives rise to convulsions and therefore is scarcely the most convenient weapon to use against them. Nevertheless, it is probably best to use ether and to carry the anaesthesia to the stage just beyond that of excitement. The anaesthetic should be continued for from five to ten minutes. If, when it is stopped, the infant starts to have further convulsive movements, the administration of ether should be recommenced and continued for a further period of five or ten minutes.

*Lumbar
puncture*

Lumbar puncture may also be mentioned, though it has also a special application in cases of convulsion arising from disease of the nervous system. In cases of repeated convulsions which do not respond to other treatment it is reasonable to draw off some cerebrospinal fluid by lumbar puncture. The benefit derived from doing so is twofold. First, the removal of cerebrospinal fluid may by itself so readjust intracranial pressure as to bring the convulsions to an end, and secondly, examination of the fluid may reveal the nature of the disorder causing the convulsions. In carrying out the lumbar puncture a needle of the smallest bore must be used. The fluid should be allowed to escape very slowly. In a small baby not more than 5 c.c. should be drained away; in older patients it is safe to remove greater quantities, according to their size.

(2)—Treatment of Underlying Causes

It now remains to discuss what steps should be taken to prevent a recurrence of the convulsions. This part of the treatment is always of great urgency whether the convulsion was slight or severe. The convulsion should be regarded as a danger signal. The disorder which gave rise to it must be identified and, if possible, cured. Clearly it would be redundant to enumerate all the causes of convulsions in infancy. Only those disorders commonly associated with convulsions will be considered; but the diversity of these will emphasize that a convulsion may be a symptom in almost any infantile disorder. *Prevention of recurrences*

The age of the patient determines to some extent the type of stimulus likely to produce a convulsion. For instance, a baby less than six months old is not particularly susceptible to acute specific infections, but he is very liable to have digestive disturbances. In this way the patient's age may give some clue to the seat of the trouble.

For convenience of discussion, the common disorders associated with convulsions may be arranged in four groups: (a) reflex irritation, (b) toxæmia, (c) diseases of the central nervous system, and (d) tetany (spasmophilia).

(a) *Convulsions arising from Reflex Irritation*

In the very young baby convulsions may follow a change of feed, as in premature weaning. The whole feeding history must always be investigated, and any glaring faults found in the method of feeding should be corrected. It does not necessarily require any gross irregularity in the proper management of a baby to provoke a convulsion. Often the rate at which food is taken is not controlled; a hungry baby will contrive to take the milk from full breasts in a very few minutes although the stomach cannot safely be filled in a shorter time than fifteen minutes. The art of checking the flow of milk can only be learned by experience. Furthermore a baby swallows some air along with the milk and should be sat up at the end of the feed to regurgitate the 'wind'. If this ceremony is omitted, the resulting colicky pain will cause screaming and sometimes a convulsion. *Digestive disturbances*

Painful peristalsis lower in the gut may equally well provide a cause for the convulsion. Usually this is associated with constipation and hard, desiccated stools; occasionally bulky, loose, undigested faeces have the same result. Treatment is not merely a question of giving purgatives or a rectal wash-out. The cause of the constipation must be removed. The commonest of the many causes of constipation in babyhood are under-feeding, too concentrated feeding and consequent water shortage, too high a mineral intake (with, again, a draining away of water by the kidney and desiccation of the stools), and, finally, an anal fissure. *Constipation*

Young babies and older infants are liable to nervous irritation from other sources. The pain from the point of an unfastened safety-pin *Focal irritation*

sticking into an infant is enough to fire off a convulsion. Mishaps of this nature are fortunately rare. An acute local infection causes just as much pain as a pin and is apt to give rise to convulsions in the same way. It is therefore essential to remove such sources of irritation. The sites of focal infections in the very young are reasonably limited. Most of them can be investigated in a routine examination.

Otitis media Otitis media can readily be recognized. Myringotomy in an infant is simple, and drainage of the middle ear is an effective means of stopping convulsions due to otitis media. Furunculosis of the external auditory meatus, a less frequent source of irritation, is not so readily relieved as is otitis media. Drops of glycerin and carbolic acid (3 per cent phenol in glycerin) relieve the pain sufficiently to stop the convulsions, and the boils can be incised and drained as they mature.

Pyelitis Pyelitis, like otitis media an acute local infection, must be excluded in every doubtful case. When it is present its treatment is of rather less certain efficacy than that of some other local infections, for the acute pyelitis of infancy tends to clear up quickly whether it is treated or not; moreover, it is only at its onset that it provokes convulsions. It is sufficient to give the patient enough potassium citrate and sodium bicarbonate to keep the urine alkaline (e.g. 5 grains of the former with 5 grains of the latter every 4 hours), and to increase his fluid intake as much as possible.

Dentition Dentition may cause convulsions. The eruption of teeth, which is sometimes painful, may give rise to a convulsion partly from continued discomfort, partly from the ensuing loss of sleep, and partly from associated digestive disturbances. Pain from teething may be suspected from the baby's age, and suspicion is strengthened if the baby rolls its head and rubs its ears as if they hurt although no abnormality in them can be found. Lancing of the gums, which is sometimes practised, should not be recommended, for it is the associated digestive upset rather than the eruption of the tooth that is likely to be responsible for convulsions. Much more efficient than incision of the gums is the use of aspirin; to a baby of six months, one and a half grains of aspirin may be given every six hours for two or three days. It is more important to treat the gastritis, enteritis, or constipation that is present at the same time.

Older infants and young children with their more stable nervous systems are not so liable to be thrown into a convulsion by these minor disorders. Until puberty has been passed, however, it is never safe to neglect the treatment of an acute focal infection as a possible cause of convulsion.

General infections The incidence of general infections increases after the first six months of life. It is therefore from that age onwards until later childhood that the occurrence of an acute fever may be heralded by a convulsion. Examples are the convulsions which occur with the sudden rise in temperature at the onset of measles, scarlet fever, or chicken-pox; a convulsion may also be the first evidence of pneumonia. The con-

vulsion is usually single and takes the place of a rigor. A convulsion at the onset of an acute fever does not imply either that the child's nervous system is unduly unstable or that the illness will be particularly severe. It is not desirable to give bromides or other drugs to prevent the recurrence of the convulsion, for such a convulsion is an isolated event associated with the onset of the illness.

If the convulsions recur during the course of a general infection of this type, complications must be suspected. Mischief may be found in the middle ear, or a lumbar puncture may reveal a secondary meningitis. The treatment of such convulsions occurring later in the illness is that of the complication giving rise to them.

(b) Convulsions arising from Toxaemias

In this section it is proposed to exclude the vague toxaemias associated with indigestion, although it may reasonably be supposed that gastro-enteritis and similar disturbances give rise to convulsions through the toxins liberated into the blood stream. It is intended to limit the discussion to the severe toxaemias such as occur in uraemia and in the late stages of hepatic diseases. From the nature of the underlying disease there may be very little that can be done with effect, the convulsions being terminal symptoms.

In uraemia, purgation, hot-air baths, and hot packs to the loins should be tried. Lumbar puncture with the withdrawal of as much cerebro-spinal fluid as escapes readily sometimes has a beneficial effect. If the uraemia arises from a temporary embarrassment of the kidneys, every effort should be made by dieting to rest these organs and restore their function as quickly as possible. When liver disease has progressed far enough to lead to convulsions there is little hope that the damage will be reparable. Lumbar puncture and withdrawal of fluid may provide a temporary benefit. Fat and protein should be withdrawn from the diet and the administration of carbohydrates pressed. The nausea induced by the sweetness of glucose or cane sugar may be circumvented to some extent by using maltose or by giving the carbohydrate as dextrin or dextri-maltose.

Uraemia

Liver disease

(c) Convulsions arising from Affections of the Nervous System

In general it may be said that convulsions appear in the course of almost any nervous disorder. The following classification is arbitrary and concerns such conditions as are met with frequently in paediatric practice.

Convulsions are common in the new-born when the labour has been prolonged or of unusual severity. Such babies have very considerable moulding of their heads. Besides the over-riding of the bones of the vault, the base of the skull may be distorted with consequent damage to the tentorium cerebelli. If the damage to the tentorium is extensive and the great veins in its margin are torn, the intracranial haemorrhage

New-born infants

thus caused kills the baby. Distortion of the base of the skull does not always lead to such gross damage and a lesser degree of bleeding may be responsible for coma and convulsions and yet be compatible with ultimate recovery. It is probable also that lesser forms of birth injury, and meningeal conditions such as oedema, may be responsible for similar symptoms, though this is difficult to prove. New-born babies thus affected lie abnormally quiet, and cannot be roused to nurse. The anterior fontanelle is often tense. They may be seized with general convulsions or a limb may twitch rhythmically.

*Withdrawal
of fluid*

Treatment of such patients by withdrawal of cerebrospinal fluid is sometimes effective, but has the disadvantage that it may start further intracranial bleeding by disturbing the established equilibrium. Recently it has been suggested that the condition may be relieved by rectal injections of hypertonic saline. A solution of sodium chloride 3·6 per cent, i.e. four times the strength of physiological saline, is used and two fluid ounces are run slowly into the baby's rectum at intervals ranging from four to eight hours. This procedure is more likely to help those patients who have oedema of the brain or meninges than those in whom haemorrhage has occurred; it has the advantage that it does no harm to those patients whom it cannot help.

Drugs

Drugs must be used cautiously in the convulsions of the newly-born. Potassium bromide 2 grains with chloral hydrate 1 grain may be used. There is a risk that the drugs will depress already damaged medullary centres, and in each case it must be decided whether the continued convulsions or an attempt to stop them by drugs will do the patient more harm.

*Young
children*

Injury to the head in older infants and in young children may result in a convulsion. The condition must be treated as a concussion. The convulsion is usually isolated and its causation from the injury easily recognized.

*Following
trauma*

More puzzling are the convulsions in childhood which occur at a greater interval after an injury to the head. The convulsions do not occur for weeks or months afterwards. A subdural haematoma is produced by haemorrhage at the time of the injury, but the incidence of the convulsions seems to depend on the organization round a clot rather than on the haemorrhage at the time of the injury. It is difficult to relate convulsions arising in this way to the comparatively mild injury which happened months before and may since have been almost forgotten. But if any such history can be obtained, and if an X-ray of the skull, taken after air has been introduced intrathecally, shows any inequality of filling on the two sides, operative treatment should be undertaken to remove the cause of such convulsions.

*In
meningitis*

Infection of the brain or its coverings occurs with some frequency in infancy and childhood. Meningitis may be either secondary or due to a primary infection by the meningococcus, pneumococcus, tubercle bacillus, or other organisms. Convulsions occur at two stages in the course of a meningitis: first at the onset in the same way as they may

usher in an acute specific fever, or later in the disorder when the inflammatory process spreads into the substance of the brain. The initial convulsion must be treated in the same way as those arising from any other infection. The management of convulsions occurring later in the course of meningitis is much more difficult. In some forms of meningitis, notably tuberculous meningitis, the prognosis is hopeless and vigorous measures with drugs such as chloral hydrate or hyoscine, and with general anaesthetics, may be taken if the convulsions are distressing the patient or his parents. In meningococcal meningitis and meningitis secondary to otitis, in which recovery may be anticipated, caution is desirable in the use of drugs. Chloral hydrate, bromides, or paraldehyde may help in limiting their recurrence, but the normal maximum doses should not be exceeded if no relief is obtained. Lumbar puncture and withdrawal of cerebrospinal fluid will often relieve such a convulsion. The essential treatment is the treatment of the disease—serum or vaccines in the case of meningococcal meningitis, efficient drainage of the ear or other focus in the secondary type. When the convulsions are due to syphilitic pachymeningitis, vigorous anti-syphilitic treatment should be instituted.

Poliomyelitis in its initial stage may give rise to convulsions which yield to simple remedies. It is unusual for convulsions to recur in the later stages of this disease. *In poliomyelitis*

Encephalitis, of whatever nature, is often associated with intractable convulsions during the whole of its course. Those which occur in the later stages, or which may persist as a sequel to it, require continued treatment such as is outlined in the next section. In this connexion there may be mentioned those forms of encephalitis which occur as a complication of measles, mumps, chicken-pox, and kindred disorders. Although encephalitis is not a common sequel, in some epidemics of these diseases it seems to occur with unusual frequency. Such a complication becomes apparent after the original disorder is beginning to clear up. Unfortunately it often leads to permanent damage to the nervous system and to persistent convulsions. Their treatment can best be considered with the treatment of other degenerative changes in the following paragraphs. *In encephalitis*

A number of conditions in which there is permanent damage to the brain are associated with recurring convulsions. The abnormality of the brain may be developmental, as in the various forms of porencephaly and in congenital hydrocephalus, or may result from birth injury. Disorders acquired after birth, encephalitis epidemica and hydrocephalus secondary to meningitis, may in a like manner lead to permanent deterioration of parts of the nervous system, and be associated with recurring convulsions. In these cases, as in the treatment of so-called idiopathic epilepsy, one is faced by a dilemma. If the convulsions are allowed to continue unchecked they will lead to further nervous degeneration; yet if sufficient drugs are used to control the convulsions the effect on the patient is likely to be unsatisfactory from the essential depressing *Associated with defects of the brain*

effect of the medicine. Each case must be treated on its merits. Often a drug or combination of drugs can be found which at a certain dose will diminish the frequency and severity of the fits without dulling whatever mental faculties remain with the patient. In finding the optimum dose it is wise gradually to increase from a small quantity until either the convulsions are relieved or it is clear that general toxic symptoms rather than relief are the only result. The drugs to be tried in this manner are: bromide, either singly as the salt of potassium, sodium, or ammonium, or combinations of all three; luminal (phenobarbitone) or luminal sodium (soluble phenobarbitone), sodium biborate, or belladonna. Luminal is preferable to its sodium salt, being more slowly absorbed, and its effect, therefore, more enduring. It is, however, insoluble and for this reason it is sometimes preferable to use the soluble luminal sodium. The initial dose of either may be $\frac{1}{4}$ grain three times a day, increased later. Borax, of which 3-grain doses are suggested, and belladonna (i.e. liquid extract of belladonna in doses of 5 minims) may be regarded as adjuvants to bromides and luminal. Alone they have little effect, but sometimes they very considerably enhance the action of the other substances.

Toxic symptoms will be recognized as undue sleepiness, rashes, or, rarely, mental disturbances. It has long been understood that the association of small quantities of arsenic, 1 minim of Fowler's solution, with the bromides, diminishes the risk of skin troubles.

Treatment by ketogenic diet is discussed in the articles on COLIFORM BACILLUS INFECTIONS (p. 285) and EPILEPSY. It is unlikely that good results will be obtained by its use in those cases in which convulsions follow gross destruction of brain substance. In the milder cases which may legitimately be classed with epilepsy, ketogenic diet deserves a full trial.

*Idiopathic
epilepsy*

To use the term idiopathic epilepsy is to evade a question of aetiology. It may be argued that an epileptic attack is always a symptom and that there is no disease epilepsy as such, also that the recurring convulsions referred to under the heading of degenerative and developmental changes might with good reason be called epileptic attacks, though in these instances the underlying mechanism can be understood. Nevertheless, it is still convenient to use the term idiopathic epilepsy for those cases in which the convulsions occur without any recognizable lesion of the nervous system, and in which there is a history of similar attacks in the family. It is a useful title for a group of conditions in which this symptom occurs and the pathology is not understood.

Epilepsy not infrequently appears first in infancy. Most epileptics begin attacks before puberty and perhaps a quarter of them before the age of three years. Epilepsy must therefore rank highly among the causes of convulsions even in infancy and early childhood.

Treatment

The treatment of epilepsy may be considered under three heads: drugs, management, and diet. Drug treatment is essentially similar to that outlined in the preceding section. If the fits tend to recur at a

regular time, e.g. at night, much can be done by regulating the time at which the medicine is taken. It is imperative that medication should be continuous and no single prescribed dose omitted. There is no short cut to cure, and experience shows that even when fits cease under treatment, this should be continued for a further three years. In the third year, the dose is gradually reduced to zero. It is likely that recurrences in later life—as for example at puberty—are due to premature cessation of treatment in childhood.

In general it may be said that it is desirable to allow the epileptic child a life as little restricted as possible. Certain amusements are clearly unwise, such as bathing, cycling, and the like, but except in the severest cases the child should be allowed games and exercise and the company of other children as far as possible. His life should be regular as to meal times, lessons, playtime, and bedtime. Eating between meals should not be permitted, and the bowels should be carefully regulated. The laudable desire to avoid undue excitement should not be allowed to render the child's life monotonous or lonely. Clearly, generalizations are difficult in the case of a malady that may show itself but as an infrequent and slight fit, or may be grossly disabling from frequency of fits and from an associated mental deterioration. It is for the latter type of case that life in a colony may be necessary, not only in the patient's interests but in those of his family.

Special diets must be considered as still under trial; some physicians have found that the number and severity of the convulsions are diminished by raising the intake of fat in the diet. The high proportion of fat to carbohydrate (protein is inert one way or the other in this matter) results in an incomplete metabolism of the fat, and ketone bodies (aceto-acetic acid and β -hydroxybutyric acid, resulting from the incomplete breakdown of fat) appear in the patient's blood and urine. It is unnecessary to increase the total calorie intake; all that is required is to increase the quantity of fat and decrease that of carbohydrate until two or three times as much fat as carbohydrate is eaten.

Diet for epileptics

It is not easy to get an infant or young child to tolerate a high-fat diet, and only too often the diet tediously elaborated is either refused by the patient or has no perceptible effect. Dehydration also has had its advocates; treatment by keeping the patient short of fluid is often simpler than causing a ketosis, but, like that method of treatment, it is not universally successful. In the youngest patients this treatment should be used with great caution, for they tolerate dehydration very badly.

(d) Tetany (*Spasmophilia*)

The changes that produce tetany are among the principal causes of convulsions in infancy and in some parts of the world appear to be responsible for the vast majority of convulsions. In Great Britain tetany does not rank so high as a cause of infantile convulsions, though it is not uncommon. It is easily recognized, and when present a straightforward and effective treatment of the convulsions is possible.

*Definition
of tetany*

Tetany is a more convenient term than spasmophilia for a group of manifestations arising from increased irritability of the nervous system. Its only disadvantage is that it is sometimes used in a more restricted sense to describe peculiar spasms of the hands and feet. Here it will be used in a general sense to cover all the associated symptoms and signs.

The calcium in the blood serum has at least two functions. One is concerned with the growth and repair of the skeleton; the other is more obscure but consists, in effect, in insulating nerves so that impulses may not be initiated by unauthorized stimuli. It is when calcium fails in this second function that tetany appears.

*Overt and
latent tetany*

The quantity of calcium normally present in the blood serum is 10 mgm. per 100 c.c.; if it falls below 6 mgm. per 100 c.c. one or other of the manifestations of tetany occurs and the condition is referred to as overt tetany. If the calcium is reduced only to between 8 and 6 mgm. per 100 c.c. the patient does not as a rule have any symptoms, but shows signs of increased nervous irritability. This stage of the disorder is regarded as latent tetany and such a patient is a likely candidate for overt symptoms if he is not treated.

Symptoms

The principal manifestations of overt tetany are convulsions, laryngismus stridulus, and carpo-pedal spasm. The convulsions differ in no way from the convulsions previously discussed. They may come on without any apparent cause apart from the tetany, or they may be initiated by trifling upsets such as would have no serious effect in a healthy infant. A convulsion passes off reasonably soon, but tends to recur until the underlying metabolic disorder is rectified.

*Laryngismus
stridulus*

Laryngismus stridulus or sudden spasm of the larynx leads to asphyxia. The patient sits up in bed, struggles for breath using all the accessory muscles of respiration, and becomes cyanosed. The spasm relaxes and breath is drawn in with a characteristic crowing sound. Laryngismus rarely lasts long enough to cause death. The attacks, however, are very distressing to the parents. They often start at night and are detected by the parents hearing a commotion in the infant's bed. The spasm is not always so complete as to lead to cessation of breathing. In some cases a laryngeal stridor with more or less dyspnoea persists for hours; in others, a peculiar characteristic 'catch' at the end of coughing may reveal to an experienced observer the presence of some degree of tetanic spasm of the larynx (see ASPHYXIA IN CHILDHOOD, Vol. II, p. 177).

*Carpo-pedal
spasm*

Carpo-pedal spasm consists of a characteristic spasticity of the hands and feet. During an attack the hands are flexed on the forearms and the fingers and thumbs are flexed at the metacarpo-phalangeal joints; the interphalangeal joints are all fully extended. The latter feature is pathognomonic. The spasms of the feet are essentially similar. The spasticity does not extend to the muscles round the elbow or knee-joints.

The phenomena of overt tetany are easily recognized; those of latent

tetany are no more difficult to appreciate. Excessive irritability of the facial nerve is recognized by tapping its branches lightly where they emerge in front of the masseter. The middle branch supplying the muscles of the upper lip is the most serviceable for this observation. If the nerve is unduly irritable there will be a twitch of the appropriate facial muscles (Chvostek's sign). Similarly, a typical carpal spasm may be elicited by constriction of the upper arm for some seconds with enough force to obliterate the radial pulse (Trousseau's sign). Hyper-irritability may be more precisely measured by testing the minimum electric currents which will produce muscular contractions when applied to a nerve. In latent tetany it will be found not only that the amperage required to produce a contraction is reduced, but also that more complex qualitative changes (anodal reversal) have taken place which alter the order of efficiency of the various types of galvanic stimuli (see ELECTRO-DIAGNOSIS).

*Symptoms
of latent
tetany
Chvostek's
sign*

*Trousseau's
sign*

Any disorder which reduces the serum calcium will lead to latent and, eventually, to overt tetany. The treatment is to cure the underlying disorder, and, during this process, to raise the blood-calcium by any convenient means. In early life the number of conditions which will reduce the blood-calcium are limited. The terminal stages of nephritis are sometimes associated with low blood-calcium and tetany. Spasms of tetany are also seen when the patient is dying of hepatitis. In neither case can much be done to relieve the tetany.

*Treatment of
underlying
causes*

Removal or destruction of the parathyroid glands leads to a fall in the level of the serum calcium and to tetany. Infants and young children are not so prone as adults to damage to parathyroids. When, however, convulsions are observed in a child who has received a severe injury to his neck, the possibility of parathyropriva tetany must be considered. If it should prove to be the diagnosis, the effective treatment is to give parathormone, an extract of parathyroid, subcutaneously, from five to twenty units daily, according to the size of the child and the extent of the damage. In addition calcium, in the form of lactate, chloride, or gluconate, must be given by mouth in as large doses as can be tolerated.

*Parathyro-
priva
tetany*

Alkalosis gives rise to tetany by producing a fall in the level of the serum calcium, the fall being one of the mechanisms by which the body attempts to counteract the loss of hydrogen ion from the blood. Prolonged vomiting leading to excessive loss of hydrochloric acid from the stomach is the commonest cause of alkalosis in infancy. The vomiting in congenital hypertrophic pyloric stenosis affords an illustration of the production of tetanic convulsions by this means. To stop the tetany the vomiting must be alleviated. In pyloric stenosis this is best done by operation. When there is a prospect of immediate relief of the vomiting, and therefore of the alkalosis, there is no need to treat the tetany, but care must be taken not to aggravate the condition by stomach wash-outs with weak alkalis. In the more intractable cases of vomiting it may be necessary to give injections of isotonic calcium chloride solution

Alkalosis

*Vitamin D
deficiency*

intravenously, or a solution of the less irritating calcium gluconate or levulinate intramuscularly. (See also ALKALOSIS, Vol. I, p. 292.)

While the foregoing disorders sometimes produce tetany and tetanic convulsions in infancy, by far the commonest cause at this age is the disturbance of calcium metabolism arising from shortage of vitamin D. Deprivation of this vitamin, besides lowering the blood phosphorus level and causing rickets, leads also to a lowering of the serum calcium which may descend to limits at which tetany occurs. The result is the same whether the vitamin shortage is in the diet, or is effected by too little exposure to the ultra-violet rays of the sun (see ACTINOTHERAPY, Vol. I, p. 188, and RICKETS). The mechanism which determines whether the phosphorus or the calcium level shall be most depressed under these conditions, remains obscure. At the beginning of treatment, when phosphorus is rapidly rising, there is risk that calcium will be temporarily depressed. It may be taken as true that all cases of active rickets are in danger of developing tetany and that this danger is at its height during the first day or so of effective treatment.

The treatment of tetany arising from vitamin D shortage is clear. The deficiency must be corrected either by giving cod-liver oil B.P., 2 fluid drachms three times a day, or by the use of one of the more concentrated forms of vitamin D, such as solution of calciferol B.P. or one of the proprietary preparations, in doses of 300 units three times a day.

At the beginning of this treatment the convulsions or other tetanic manifestations should be controlled by large doses of calcium salts by the mouth. Twenty grains of calcium chloride dissolved in water and given three times a day is often tolerated for a few days. Alternatively, 40 grains of calcium lactate or calcium gluconate may be given. Occasionally the symptoms of tetany become so urgent that it is necessary to give a calcium salt intravenously or intramuscularly in the manner referred to under gastric tetany. The administration of calcium, however, is only a temporary phase in the treatment, the essential part being the restoration of a normal calcium metabolism by giving adequate quantities of vitamin D.

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CORD, SPINAL

See SPINAL CORD DISEASES

CORDS, VOCAL

See LARYNX DISEASES

CORNEA, INJURIES AND DISEASES

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Reference may also be made to the following titles:

CONJUNCTIVA, INJURIES AND DISEASES EYELIDS, INJURIES AND DISEASES	TRACHOMA UVEAL TRACT DISEASES
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1.—CONGENITAL AFFECTIONS

260.] Microcornea is present in small ill-developed eyes, and the cornea may be only two-thirds of the normal size.

Astigmatism results when the curvature of the cornea is not equal in every direction, with the result that rays of light transmitted to the retina do not come to a focus at any one point (see ASTIGMATISM, Vol. II, p. 197).

Interstitial keratitis is rare at birth. The cornea is opaque in the absence of injury to the corneal epithelium (see p. 425).

Dermoid tumours at the junction of cornea and conjunctiva require ablation (see CONJUNCTIVA, INJURIES AND DISEASES, p. 374).

2.-INJURIES

Foreign bodies may lodge on the surface or in the substance of the cornea, or may penetrate into the interior of the globe. They may be of any composition, and should be looked for on the cornea whatever the ocular condition of which the patient complains.

The eye should be anaesthetized with a 4 per cent solution of cocaine hydrochloride, and the foreign body removed with a spud or a cataract needle. Unless the damage has been severe the eye need not be kept under atropine afterwards. Foreign bodies in the substance of the cornea or possibly in the globe demand the attention of an ophthalmic surgeon. Magnetizable foreign bodies of a certain mass, which are deeply embedded in the cornea, may be extracted after a tunnel has been made through the corneal tissue for the introduction of the pole of the giant magnet. *Treatment*

Abrasions of the superficial corneal epithelium constantly occur as the result of trivial injury. They are easily recognized by placing a few drops of soluble fluorescein solution (soluble fluorescein 2 per cent in sterilized distilled water) on the cornea and adding a little water, when any abrasion is stained green. In the absence of gross sepsis the epithelium is rapidly regenerated and remains clear. In ordinary cases no treatment is required beyond some simple lotion, such as physiological saline, or, if more severe, a good deal of comfort is obtained by bandaging the eye for 24 hours. *Abrasions*

Wounds of the cornea which do not penetrate to the interior of the globe heal rapidly unless they are infected, in which event an ulcer results. Penetrating wounds are much more serious. First the globe may be infected, which generally leads to the loss of the eye. Secondly the entrance of a sharp object through the cornea into the anterior chamber, and its withdrawal, allows the aqueous humour to escape, during which process a tag of iris is liable to be washed into the wound and to prolapse through it. In all such cases immediate surgical treatment is required. The possible presence within the globe of a foreign body must be carefully considered (see p. 366). The prolapsed tissue, being certainly septic, should never be returned into the anterior chamber nor should atropine be given to effect this; it should be seized with forceps, and, while stretched, severed with scissors; the proximal parts of the iris should then retreat into the anterior chamber and should not remain in contact with the wound. This is a skilled ophthalmic operation. If no facilities are available for the performance of such an operation immediately, if for instance the accident occurs where specialist help is not available, the resulting delay may seriously impair the eye. *Wounds*

Chemical injuries, due to the entrance of lime, acids, or alkalis, may produce more or less complete opacity of the cornea at first, followed by denudation of the corneal epithelium. The injury to the conjunctival *Chemical injuries*

epithelium leads to adhesion, partial or complete, of the lids to the globe, a condition known as symblepharon.

Lime burns are a common accident among bricklayers' labourers and require immediate attention. All fragments of solid matter must be removed under local anaesthesia; if there is severe blepharospasm the lids should be infiltrated with novocain, 1 per cent, in order to facilitate removal, and the conjunctival sac filled up with castor oil. To prevent symblepharon a glass rod, which has been dipped in castor oil, should be swept round the upper and lower fornices daily. In order to put the eye at rest and to minimize the results of the iridocyclitis which is generally caused, atropine ointment 1 per cent should be used twice a day.

Injuries by acids or alkalis not infrequently occur in chemical laboratories and the physical results are those previously described, but the initial treatment should be immediate irrigation with a large volume of normal saline solution, or of tap water if the saline solution is not immediately available. The subsequent treatment is the same as for lime burns.

*Gas injuries
in warfare*

The instructions for the treatment of gas injuries in warfare given in *Air Raid Precautions* issued by H.M. Stationery Office are as follows: 'The only first aid for Blister Gas in the eyes is free washing with either plain warm water, normal saline, or sodium carbonate solution about 10 grains to the pint. The points of importance are that the washing should be free, best done with some form of douche-can with rubber tubing and a nozzle, and that it should be carried out at the earliest moment after contact.' The subsequent treatment is that described above.

The ocular injury by mustard gas, though exceedingly painful, usually heals rapidly under treatment, but Mayou described a more serious case. Six days after being 'blinded' the patient had intense injection and photophobia in both eyes. The surface epithelium of the cornea was slightly roughened but intact; in its superficial layers, about 2 mm. from the margin, there was a yellow band of purulent infiltration, which gradually absorbed after five weeks without the superficial epithelium breaking down. (See GASSING AND POISON GAS.)

In some cases a bacterial infection of the roughened cornea may occur with ulceration. The treatment is as for ulcer of the cornea.

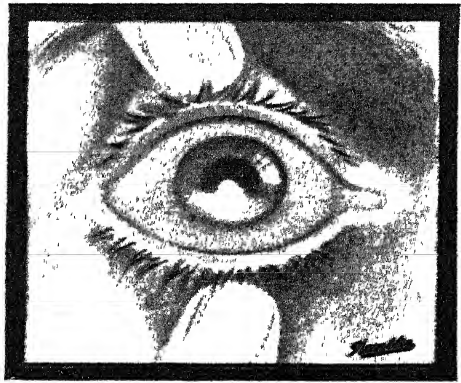
3.-ULCERS

*Ulcers,
traumatic or
infected*

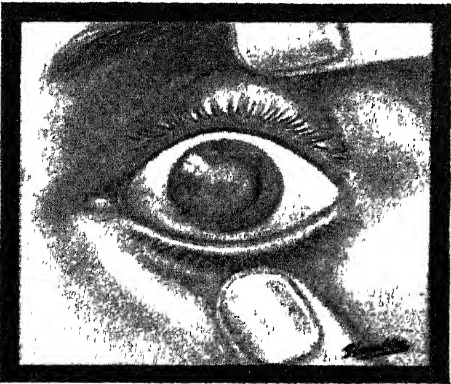
Ulcers of the cornea, except those due to herpes ophthalmicus, are in the first instance traumatic, in that they are initiated by a breach of the corneal epithelium produced either by violence or by chemical means. Micro-organisms and their chemical products only rarely cause such a breach, for the healthy conjunctival sac contains many bacteria some of which may be pathogenic. The destruction of a few superficial cells, as by the action of a particle of dust, may allow bacteria access



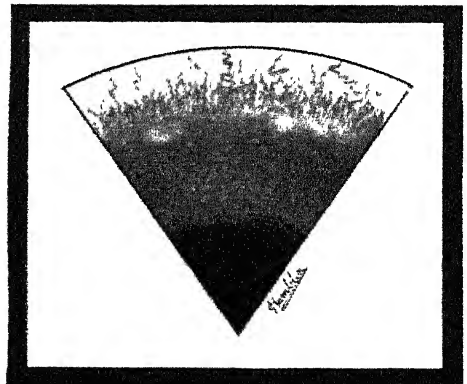
A



B



C



D

A.—Epithelioma of limbus. B.—Ulcer of cornea with hypopyon. C.—Interstitial keratitis. D.—Advancement of limbal vascularization

PLATE X

to the deeper layers with resulting damage. Thus, an abrasion which in a healthy conjunctival sac would heal in a few hours may, in an infected sac, result in a necrotic ulcer. Infective material gains access to the conjunctiva from a septic lacrimal sac (via the lacrimal duct), a diseased nasal mucous membrane, infected tonsils, or the mouth which is never sterile.

The symptoms are at first discomfort, photophobia, and lacrimation, and later pain which may be severe. On examination there is always hyperaemia of the conjunctiva and a grey spot on the cornea which stains with fluorescein solution. If untreated this increases in extent, breaking through Bowman's membrane and infecting the corneal stroma. Iritis is likely to ensue from absorption of the chemical products of inflammation, and there results exudation of white cells, which collect at the lowest part of the anterior chamber like a white half-moon, a hypopyon (see Plate X, B). With increased destruction of corneal tissue Descemet's membrane, which forms the last barrier against the anterior chamber, gives way, aqueous humour rushes out, and the iris prolapses. The iris tissue, blocking the gap, revivifies by new vascularity the edges of the corneal gap, and, if severe sepsis with resulting panophthalmitis does not intervene, a firm scar is produced and the anterior chamber re-forms.

A phlyctenule of the cornea may occur in the same manner and for the same reasons as a phlyctenule of the conjunctiva (see Plate IX, B and p. 370). Phlyctenules are often multiple. They are amenable to treatment, as described on page 370, but scarring is left, with resulting diminution of visual acuity. *Phlyctenular ulcer*

Dendritic ulcer is a small arborescent destruction of the corneal epithelium; like other ulcers it is made more evident by staining with fluorescein. It is frequently associated with oral sepsis. It may occur in febrile states. The treatment is to anaesthetize the eye, to stain the ulcer with fluorescein and note its extent, and to apply pure carbolic acid on a sterilized, dry, pointed wooden match along its ramifications. *Dendritic ulcer*

Mooren's rodent ulcer of the cornea is a slowly increasing and intractable ulcer which begins at the periphery and may extend all over the cornea; hypopyon never occurs and the ulcer never perforates. *Mooren's ulcer*

Examination for an ingrowing eyelash, or a foreign body on the cornea or under the upper lid, must first be made, and these if present must be removed. Next, a finger must be pressed over the lacrimal sac to see if pus regurgitates through the puncta; if it does the sac must either be frequently irrigated through the lower canaliculus or dealt with by operation. The third procedure is to see if there is any oral sepsis in the mouth, such as unhealthy stumps or teeth; if present they should be immediately removed, and if there is nasal sepsis this also should be treated by antiseptic douches and ointment. *Treatment of ulcers*

Local treatment is carried out by frequent irrigations of the conjunctival sac with physiological saline, or with a weakly antiseptic fluid, the best being a dilution of eusol solution, 1 part with 9 parts. *Irrigation of conjunctival sac*

of sterile water. Between the irrigations the patient should continually be mopping his eyelids with cotton-wool dipped in the same solution, so that a little enters between the lids. If the conjunctiva is red and oedematous it should be swabbed daily with a pledget of cotton-wool dipped in a 1 per cent silver nitrate solution.

Treatment of associated iritis As ulceration of the cornea is usually accompanied by iritis, the pupil should be kept moderately dilated by 1 per cent atropine sulphate solution. In the majority of cases if the above treatment is sedulously carried out rapid improvement occurs. However, if the ulcer extends, it is necessary to scrape its base and edges with a small sharp spoon after cocainization, next to dry it with blotting paper, and then to apply pure carbolic acid to the ulcerated area; alternatively the galvano-cautery may be applied.

Local treatment of ulcer

If the cornea gives way and the iris prolapses, the instillation of solution of atropine sulphate should be stopped and no more cauterization should be attempted. Healing, in the absence of gross sepsis, generally takes place rapidly.

Treatment of hypopyon When a hypopyon is present its absorption is aided by the application of heat. Occasionally it may be advisable to evacuate it; the pus is sterile on culture.

Sequels to ulceration The healing of a superficial ulcer of the cornea results in a slight opacity or nebula, whereas the cicatrization of a deeper ulcer results in a dense opacity or leucoma.

Perforated ulcer Perforation of an ulcer results in adhesion of the iris to the back of the cornea at the point of perforation (anterior synechia). It is accompanied by iritis, and adhesions of the iris to the capsule of the lens may develop (posterior synechia). Either of these conditions may be followed by increased tension of the eye or secondary glaucoma. As a result of increased tension the cornea may bulge forwards as an anterior staphyloma.

After a perforated ulcer has healed with incarceration of iris in the cornea, it may be advisable to perform an iridectomy as a prophylactic measure against secondary glaucoma.

Treatment of leucoma of cornea Dense leucomas of the cornea may reduce the visual acuity to infinitesimal proportions, besides being very unsightly. To improve the appearance, the white leucoma may be darkened by tattooing, an operation which may be carried out in various ways by an ophthalmic surgeon. When the sight is very greatly reduced in both eyes as the result of leucomas, and it is believed that the lens remains clear and that the retina is undamaged, it may be possible to remove a portion of the leucoma and to substitute for it clear corneal tissue obtained from another person. It is then necessary to find a patient with the same blood-grouping, who is about to have an eye with a clear cornea removed, and to obtain the required graft.

4.—SYMPTOMATIC AFFECTIONS

In keratitis punctata or keratic precipitates there are little aggregations of leucocytes which have been extravasated from the vessels of the ciliary body and adhere to the posterior surface of the cornea in its lower part. They signify inflammation of the iris and ciliary body. To detect them it is often necessary to condense a bright light with a lens on to the cornea. When the tension of the eye is increased the cornea may exhibit a characteristic steamy appearance from oedema of its surface.

Keratitis punctata

Steamy cornea

Interstitial keratitis or parenchymatous keratitis (see Plate X, c) is a manifestation of congenital syphilis and very rarely of the acquired disease.

Interstitial keratitis

It is essentially a uveitis with secondary involvement of the cornea. The choroid usually shares in the inflammation; there is irido-cyclitis, and keratitis punctata may be present; hence blocked pupil, secondary cataract, or secondary glaucoma may result.

Morbid anatomy

The clinical signs at first are dim gray patches in the deeper layers of the cornea, which become confluent and produce a ground-glass appearance. Vascularization begins by the penetration, from the periphery of the cornea, of vessels derived from the deeper vessels of the sclerotic. As a result a salmon-coloured patch appears in the cornea; this never breaks down, and finally undergoes resolution with a varying amount of cicatrization. There is a heritage of fine obliterated vessels in all cases of old cured disease. The symptoms may be severe with pain and photophobia. Usually one eye is affected first between the ages of 5 and 15 years, but it has been seen at birth. The other eye is usually affected later, occasionally not until several years after the first eye has been attacked.

Clinical picture

The clinical diagnosis is confirmed by obtaining positive results with Wassermann's reaction and Kahn's test, and also by the pegged and notched upper central incisor teeth of the permanent dentition (Hutchinsonian teeth).

The local treatment consists in keeping the pupil dilated with atropine sulphate solution, 1 per cent, and by the application of heat to allay pain. On no account should strong lotions be used. The general treatment consists in the active and continued treatment for congenital syphilis.

Treatment

Neuro-paralytic keratitis has as its characteristic feature a desquamation of the corneal epithelium. This may be followed by erosion of the corneal tissue, iridocyclitis with hypopyon, perforation of the cornea, and panophthalmitis. There is no lacrimation and no pain. The condition is due to anaesthesia of the cornea and conjunctiva allowing slight injuries to pass unnoticed, but also to trophic changes in the corneal nerves. It results from paralysis of the fifth nerve, usually caused by changes in the Gasserian ganglion, brought about by syphilis or surgical ablation. In all cases in which the cornea

Neuro-paralytic keratitis

Treatment

is anaesthetic great care should be taken to prevent accidental injury. A lotion should be used daily, such as zinc sulphate solution 0.25 per cent, protective goggles should be worn out of doors, and a drop of castor oil should be instilled into the conjunctival sac at night. If any desquamation appears the pupil should be kept dilated with atropine and the eye should be protected by a pad and bandage; improvement may occur, but when the pad is removed ulceration often follows. The invariable treatment must then be by median tarsorrhaphy. This may be carried out without anaesthesia since the skin of the lids also is anaesthetic. An assistant seizes the upper lid at either extremity with forceps, and a rectangular area of mucous membrane, 8 to 10 mm. long, is removed from the free border of the lid immediately posterior to the lashes; the lower lid is treated in the same way; three silk sutures are then passed through the skin so that they come out at the posterior edge of the bared surface; and they are then carried through the bared surface and skin of the other lid, so that when they are tied the bared surfaces come into contact. The sutures should be removed after three days, when firm union should have been effected. There is no difficulty in disuniting the lids when desired, after which the cornea may remain intact for a long time, though always liable to a recurrence of the trouble.

*Herpes
febrilis*

Herpes of the cornea is the manifestation of a specific virus infection. It occurs in febrile states, such as broncho-pneumonia, and may accompany other facial manifestations of herpes. In most cases it is unilateral. Vesicles the size of a pin's head form on the cornea, and there is much lacrimation and blepharospasm. The vesicles rupture, but heal rapidly, leaving no opacity except in severe cases. The cornea is not usually anaesthetic.

*Herpes
zoster*

In herpes zoster ophthalmicus a similar condition occurs, but here the cornea is anaesthetic. The typical efflorescences on the skin occur in the areas of distribution of one or other of the branches of the fifth cranial nerve and are preceded by intense neuralgic pain. The disease is due to a lesion of the Gasserian ganglion of the same type as that found in the posterior root ganglia in herpes zoster. The ocular symptoms are usually more severe than in herpes febrilis.

Treatment

The eye should be put at rest by the instillation of a solution of atropine sulphate 1 per cent, a drop of castor oil should be placed in the conjunctival sac, and the eye occluded with a pad and bandage.

*Keratitis
profunda*

Although keratitis profunda is not at all common I have two cases under my care in hospital at the time of writing. It is characterized by a lymphocytic exudation, single or multiple, into the middle layers of the cornea. Since in both cases the corneal epithelium is intact, a pre-existing injury must have been present to allow of infection from without. In one of the cases there was severe oral sepsis, but in the other case there is no discoverable focus of sepsis and the patient is apparently healthy.

Treatment

Atropine should be instilled to keep the pupil dilated and put the eye at rest, and heat should be applied by means of an electric warmer or frequent hot compresses.

5.—DEGENERATIONS

Arcus senilis is a ring-shaped opacity just inside the periphery of the cornea, and usually appears about middle age. It is due to a fatty degeneration of the corneal stroma, but has not any pathological significance (see Plate IX, c). *Arcus senilis*

Conical cornea or keratoconus is a bulging forward of the central part of the cornea in the form of a cone; it occurs without inflammatory signs and the cause is obscure. It is much commoner in women than in men, and develops about the age of 18 to 25. When both eyes are affected the use of contact glasses may be of value if the visual acuity is greatly reduced. *Keratoconus*

Calcareous deposits may occur in the superficial layers of the cornea, either on Bowman's membrane or between the lamellae of the stroma. They form fine granules when first deposited, and later laminae or round and irregular nodes of various sizes. They may cause considerable depreciation of visual acuity. The condition is rarely met with. No treatment is of avail. *Calcareous degeneration*

6.—TROPICAL AFFECTIONS

Trachoma is the most common of all affections of the cornea in tropical or sub-tropical countries. The lymphoid infiltration characteristic of trachoma (see TRACHOMA) appears at the upper periphery of the cornea almost simultaneously with follicles of the conjunctiva. This can be seen beneath the epithelium as a faint grey appearance with new vascularization, and finger-like vessels derived from the superficial conjunctival blood-supply extend into the clear cornea (see Plate X, d). This is a very important diagnostic point. Besides the peripheral follicles, lymphoid deposits may occur anywhere on the cornea and leave little facets when they cicatrize. Often the epithelium overlying the follicles becomes destroyed and an ulcer results; when this heals an opacity is produced. The network of blood-vessels or pannus which is seen in many old cases of trachoma has its inception in the irritation caused by the specific lymphoid invasion of the cornea and remains after cicatrization has occurred, to provide emergency nutrition for the cornea when much of the normal lymph channel system is obliterated. It is therefore obvious that no attempt must be made to 'cure' pannus. *Trachoma*

The general features of leprosy are dealt with in the article under that title. In the following paragraphs are briefly described the ocular changes which occur in this disease. *Leprosy*

The eyebrows and lids. The hairs of the eyebrows and lids are shed. In nerve leprosy the skin becomes anaesthetic, and ectropion develops; in nodular leprosy there is thickening of the eyebrows, and the nodules may ulcerate.

The conjunctiva and cornea. Sensation is diminished or abolished. The conjunctiva may be attacked by leprotic nodules which spread deeply, causing entropion or trichiasis. The episcleral nodule at the limbus, usually first seen in the upper temporal quadrant, is characteristic, but must be differentiated from an episcleral growth. Punctate keratitis occurs as small ill-defined round dots, greyish in colour, which lie beneath Bowman's membrane in the corneal stroma. Interstitial keratitis occurs as a sequel to involvement of the ciliary body; in the stroma are seen infiltrates which do not clear up; keratic precipitates are found on the posterior surface of the cornea.

Iris and ciliary body. Iritis and iridocyclitis, usually chronic, are seen occasionally. In the iris appear a number of discrete spots, on some of which may be fine pigment particles; these are pathognomonic of leprosy.

No other parts of the eye show any characteristic change. The lepra bacillus may be found in the conjunctival secretion and in leprotic nodules.

Treatment

The treatment is described fully under the title LEPROSY.

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CORNS AND BUNIONS

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Reference may also be made to the following title:

SKIN TUMOURS

1.-CORNS

261.] The corn is a local thickening or callosity of the skin about a central, horny peg (clavus or nail) which, growing downwards, produces a cup-like depression in the dermis, and a pressure atrophy of the papillae, and may be complicated by painful congestion, particularly susceptible to changes in the weather. The corn may become infected and suppurate; it may lead to the formation beneath it of a sac or bursa, which is in the nature of a protective mechanism. *Definition of corn*

It is usually produced by local pressure, sometimes temporary and sometimes of long duration. Patients of a rheumatic diathesis are particularly liable to develop corns in middle life, and similar, but less hard, callosities which come and go over the joints of their fingers. Callosities may develop around warts on the feet, in the form of hard, raised circles of horn having as their centre filiform summits of deep plantar warts. They may form over joints in patients suffering from such diseases as tabes, leprosy, or peripheral neuritis. The centres of these corns may crack and ulcerate, and the condition is then referred to as perforating ulcer. The corn must be sliced away thoroughly before there is any hope of the ulcer edges approximating. Corns between the toes in persons with a tendency to excessive perspiration may become foetid and extremely painful. *Causes*

The pressure produced by the conical tips of stockings is as potent as are ill-fitting shoes in the production of corns. In all cases care should be taken to differentiate the condition from local callosities

that may result from prolonged courses of treatment by arsenic. On the sole of the foot the possibility that plantar warts may be masked by a great amount of peripheral horny overgrowth must never be forgotten; a chronic patch of psoriasis upon the sole has been referred to as *clavus*.

Chiropody

An extensive business has grown up in treating corns of the feet. In Great Britain there are three groups of chiropodists: (i) those belonging to the British Association of Chiropodists, (ii) those belonging to the Incorporated Society of Chiropodists, and (iii) the most numerous group, untrained practitioners working, without certification or fellowship, either in the back rooms of boot emporiums or privately. The magnitude of this business is shown by the frequency with which chiropody exhibitions are held in the larger cities of Great Britain, the Continent, and the United States, and by the fact that they are attended by many prominent instrument makers. At present there is no official regulation of chiropody but a Charter is being prepared for submission to the Privy Council and is delayed only by the internal dissensions of the chiropodists themselves.

Treatment

If at all possible, properly shaped footwear should be advised. The removal of the callosity needs practice, aseptic and sharp instruments, a good light, and much patience. Subcutaneous injections for local anaesthesia in painful cases are of great assistance; freezing with ethyl chloride is a poor substitute. When there is underlying suppuration the corn must be removed immediately, under gas if necessary, as cellulitis and septicaemia have followed in neglected cases. Moderate cases respond well to the repeated application of strong salicylic acid paints (e.g. salicylic collodion B.P.C.) or to the application and daily renewal of heated plasters containing at least 30 per cent of salicylic acid in their adhesive substance, as in rubber salicylic plaster B.P.C. To relieve pressure, the affected toe can be wrapped in springy natural wool, which eases pressure more diffusely and satisfactorily than ring-shaped pads. The regular application of surgical spirit, followed by a dusting powder containing equal parts of boric acid and talc, will keep tender skin in good condition and help to prevent the development of corns in those who have become habituated to wearing tight footwear.

2.—CUTANEOUS HORN

262.] *Cornu cutaneum* (cutaneous horn) is the term applied to horny excrescences variable in shape and similar in structure to horns of animals. They are usually hard, dry, and brownish, and twisted or bent. They may be found on the head or on any part of the body; when they are knocked off, a new horn forms from their red, oozing base. Old age is a predisposing cause and the condition should always be regarded as possibly malignant. Cutaneous horns should be excised and radium applied to their bases. Similar callosities are found on the sides of deformed feet and over the bones of hands subject to special

pressure in certain trades, e.g. cube sugar workers. The latter are known as occupational stigmata and do not call for treatment; when the work is given up they disappear; when the orthopaedic deformity is corrected the pressure callosity also disappears.

3.—BUNIONS

263.] Bunion is the ancient and satisfactory English term for hallux valgus. It is a gross deformity produced by outward bending of the big toe. It causes a squeezing deformity of the other toes, and sometimes the big toe over-rides one or two. In addition to the skeletal deformity there is often formed, between the prominent semi-exposed head of the first metatarsal bone and the skin, a sac or bursa in a natural attempt to make skin friction over the protruding bone as easy and tolerable as possible. This deformity is not infrequently also accompanied by a grave degree of flat foot. *Definition of bunion*

By many the term bunion is restricted to the adventitious synovial buffer between the skin and the bone, but properly the term covers the whole deformity.

The condition is started by the wearing of tight woollen socks which make a continuous traction towards the middle of the foot which no young tissues can long withstand. Then the condition is aggravated and made permanent by the wearing of pointed shoes, the sides of which converge towards a central point. Walking produces fatigue, and a multitude of slight injuries excites an inflammatory arthritic process in the joint with the formation of bony thickenings (exostoses). Frequently, also, the bursa becomes the site of chronic inflammation; it becomes tense with serous exudate and occasionally suppurates with intense local pain. *Pathogeny*

The orthopaedic surgeon and the skilful bootmaker, however, can correct the deformity in its early or late stages. Corrective splints can be applied, or the enlarged head of the metatarsal bone can be excised. To Mayo we owe the idea of dissecting off a semicircular flap of skin just opposite the joint. The head of the bone is removed and the bunion is inserted into the joint to serve as a new synovial cavity. *Treatment*

Pain can be greatly relieved by the local application of one-third of an erythema dose of X-rays, repeated at fortnightly intervals, three times in all. When the whole foot aches, relief is given by the application of infra-red rays for twenty minutes at a time, the whole foot being placed within the focus of the source of radiation. Minor cases are alleviated by the administration of aspirin, and massage night and morning with a liniment of menthol 60 grains dissolved in 1 fluid ounce of olive oil. The distended sac can be punctured with a hypodermic needle, and the tension and pain relieved by the withdrawal of a little blood-stained fluid and the injection of a few drops of a 1 per cent solution of procaine hydrochloride (novocain).

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CORONARY ARTERIES

See ANGINA PECTORIS AND CORONARY THROMBOSIS,
Vol. I, p. 547; ARTERIAL DISEASE AND DEGENERATION,
Vol. II, p. 39; and HEART

CORONERS AND INQUESTS

BY F. TEMPLE GREY, M.B., M.CH.

OF LINCOLN'S INN, BARRISTER-AT-LAW; DEPUTY CORONER
EAST MIDDLESEX

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Reference may also be made to the following titles:

DEATH, SUDDEN AND UNEXPECTED
POST-MORTEM EXAMINATION, MEDICO-LEGAL

1.—THE CORONER

264.] The office of coroner is a peculiarly Anglo-Saxon institution and is to be found throughout the British Empire—excepting Scotland—and with considerable modifications in the United States of America. In the United Kingdom, the coroner's duties are to inquire into unnatural deaths, i.e. from violence, poison, or otherwise, deaths the cause of which is unknown, deaths of prisoners, lunatics, foster children, and so forth. *Duties*

In the United Kingdom—except Scotland—coroners are appointed by county and borough councils; and barristers, solicitors, and registered medical practitioners of five years' standing are eligible for appointment. Once appointed they are responsible for their conduct to the Lord Chancellor only. *Appointment and qualification of coroners*

2.—NOTICE OF DEATH

It is the common law duty of every person to give information which may lead to the coroner having notice of circumstances that would make it necessary to hold an inquest. *General duty to give information*

The question whether or not to report a death to the coroner often puzzles medical men even of long experience; and yet the indications

are fairly definite. The cardinal point to bear in mind is not: 'Do I know the exact cause of death?' but rather: 'Have I any reason to suspect that this death is not a natural one?' If the practitioner is satisfied that the death is a natural one, although only a probable cause of death can be given, it is his duty to give a death certificate. In a puzzling or interesting case he will of course have tried to get the permission of the relatives for a necropsy, but he cannot properly use the coroner as a lever to obtain this examination, for unless he is prepared to certify the probable cause of death (i.e. that it is a natural death) he is not entitled to perform the necropsy without instructions from the coroner.

*Categories of
cases to
report*

Most cases reported to the coroner reach him from the practitioner, because he is unable or unwilling to give a certificate. Many cases, however, are reported to the coroner by the registrar after issue of the certificate, and indeed the best guide to the sort of case to report to the coroner is to be found in the Registrar-General's instructions to local registrars of deaths, which are to report any deaths they may discover, either from a medical certificate or otherwise, which fall into any of the following categories: (1) those which were not under medical care in the last illness; (2) those in which death appears to be unnatural, or directly or indirectly caused by accident, violence, or neglect, or attended with circumstances of suspicion, or the cause of which appears to be unknown; (3) in which death has followed abortion, anthrax, compressed-air illness (caisson disease), industrial disease of the lungs, and all kinds of poisoning, including alcoholic; (4) in which death has occurred after an operation necessitated by injury, or under an operation, or before recovery from the anaesthetic; (5) in which the patient has not been seen by a medical man within 14 days before death; (6) in which still-birth is alleged but there is reason to believe that the child was born alive.

With regard to industrial diseases, it is better to report any death which appears to be connected with the work of the deceased, whether the disease is a scheduled industrial disease or not. As for chronic alcoholism, it is—in general—not fair to put this on the certificate as a cause of death merely because deceased was in fact in the habit of drinking a good deal, unless fatal damage to the viscera due to alcohol has been found after death by an expert pathologist; it is particularly unfair if the cause of death is otherwise plain.

A duty is laid by law upon others besides the registrar to inform the coroner about deaths of the following persons: (1) mental patients or lunatics; (2) mental defectives under certain conditions; (3) prisoners; (4) habitual drunkards in a retreat; (5) children under 9 years taken care of for reward.

In some cases no question of giving a certificate arises, as for instance in crimes of violence which will have to be taken up by the police. With regard to abortion, if death results from the criminal act of the deceased or of some other person or persons, it is a doctor's duty as a citizen to report facts within his knowledge. It is, however, no part

of a doctor's duty to act as an inquisitor, and there should be no difficulty in treating a case of abortion without asking the patient to incriminate herself.

Much unnecessary reference to coroners would be avoided if practitioners would exercise more care in filling up death certificates. A common fault is to give a string of diseases, sometimes even omitting the real cause of death. The term heart failure should be avoided; if the heart is diseased and death is the result of this disease, it suffices to enter the name of the lesion. Another common mistake is to give the cause of death as 'cerebral haemorrhage' without mentioning the condition behind it; if the cause is not given, the registrar may think the condition was due to accident. 'Fibrosis of the lungs' should be followed by 'non-industrial' in brackets, if such is the case. The condition which is responsible for a septicaemia must be mentioned, and if an osteomyelitis is non-traumatic it is well to say so. On the other hand, a 'one line diagnosis' is useful if the condition diagnosed was a sufficient cause of natural death—e.g. lobar pneumonia.

If it is desired to report a case to the coroner, it is well not to waste time by putting the report in the post; it is better to send for the coroner's officer, who will take particulars and transmit the report promptly to the coroner. If the practitioner does not know where the coroner's officer is, the local police will find him.

3.—THE INQUEST

In the United Kingdom before 1927, the coroner was bound to hold an inquest on all deaths of which he took cognizance, but since that date he can dispense with an inquest if a natural cause of death is revealed by post-mortem examination. Actually more than half the deaths reported to the coroner are passed by him without inquest; these are cases of sudden and unexpected death, or cases in which deceased was not attended in his last illness by a medical man.

When he holds an inquest, the coroner may, since 1927, except in certain cases, sit without a jury. The jury number seven to nine and may give a majority verdict. If the jury choose to add a rider the coroner must accept it. The coroner's inquest is an inquiry, not a trial; there are no parties nor is there any suit. Consequently his finding, or the verdict of his jury, does not settle anything about the cause of death that may not be re-opened in further proceedings. An irregular inquest may be quashed by the High Court and a *melius inquirendum* issued. Such irregularities would be: holding an inquest on a Sunday, Good Friday, or Christmas Day; jury insufficient in number, where a jury is required; failure by the coroner to view the body; failure or refusal to receive relevant evidence. Counsel and solicitors appear only by permission of the coroner; they have no right of audience since there is no suit but only an inquiry. Evidence is given on oath, though

*Precautions
in filling up
death
certificates*

*Inquest
procedure*

the coroner may, and frequently does, take evidence from young children not under oath. He is not strictly bound by the rules of evidence, but reputable coroners follow these very closely. He has wide powers within his district and can summon anyone who can give relevant evidence, except the King himself and persons enjoying diplomatic immunity, to attend his inquest and can compel such attendance; and he can commit for contempt of his court within such court, but not outside. He has no jurisdiction over the body of a person protected by diplomatic immunity.

In court the medical witness should stand up when the coroner enters or leaves the court and address him as 'Sir'. These marks of respect are not personal to the coroner but are due to his office, for he represents for the time being the Sovereign, and in legal theory the King is everywhere present in his courts.

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CORYZA

See COLDS, p. 271

COUGH

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Reference may also be made to the following titles:

ADENOIDS	LARYNX DISEASES
ANEURYSM	LUNG DISEASES
BRONCHIECTASIS	PHARYNX DISEASES
BRONCHITIS	TONSILS DISEASES
HEART	TUBERCULOSIS

1.-DEFINITION

265.] Cough is essentially a protective act which eliminates deleterious material from the air-passages of the lungs and prevents its entrance into the bronchial tree. It is effected by a quick inspiration, immediately followed by a sudden and forcible expiration.

With the exception of pain, cough is probably the most common symptom about which a patient consults his practitioner, seeking advice on account of the irritation and interference with his work, or because of insomnia and general disturbance to his mode of life. Frequently cough brings the patient to his doctor because he fears a serious underlying cause, and it is not surprising that, after careful examination and

an assurance that the symptom is not due to any definite organic disease, the patient, without any direct treatment, loses a cough which may have been present for a considerable time.

Another type of cough causes no worry to the patient but considerable anxiety to friends and near relations. The contrast between the patient's own description of his cough and that given by his companion is usually marked. The patient makes light of the symptom saying that it is trivial and due in all probability to smoking cigarettes. The anxious parent or relation, on the other hand, generally exaggerates the cough, describing it as incessant and as daily becoming worse. It often happens that the patient makes light of the symptom from fear, which may be as great as, if not greater than, that of the relative.

2.—CAUSES OF COUGH

The following is a classification of the causes of cough: (1) local causes, (2) conditions affecting the lungs or pleurae, (3) pressure on the respiratory tract, (4) reflex causes, and (5) nervous causes.

(1)—Local Causes

The most common local causes are enlarged and inflamed tonsils and adenoids (particularly in children), long uvula, pharyngitis (which often is associated with dyspeptic conditions), laryngitis, and tracheitis.

*Tonsils and
adenoids*

The cough due to enlarged and inflamed tonsils and adenoids occurs chiefly when the patient is in bed and more particularly when lying on the back; the explanation is that in the recumbent position the secretion tends to trickle down the trachea, causing irritation and cough. Cough due to a long uvula also usually occurs at night when the patient is in bed; but it may be emphasized that 'long uvula' is an unsatisfactory diagnosis, and I have not seen much success from shortening the uvula in these cases. Even when this seems to be the diagnosis a very careful search should be made for other causes.

Pharyngitis

The 'pharyngitis' cough, if associated with dyspepsia, as very often it appears to be, tends to occur chiefly in the morning, and though apparently loose is often purposeless as regards the expulsion of secretion. It is quite distinct from the cough associated with laryngitis, which is raucous, painful, and often accompanied by hoarseness, sometimes to an extreme degree. In tracheitis the main feature of the cough is that it is often very severe and totally out of proportion to the physical signs found in the chest or to the disturbance in general health.

Laryngitis

(2)—Conditions affecting the Lungs or Pleurae

Under this heading attention may be drawn to the cough of acute and chronic bronchitis, acute pleurisy, pulmonary emphysema, bronchiectasis, pulmonary tuberculosis, fibrosis of the lungs, and pulmonary neoplasms. The cough of acute bronchitis is usually painful and gener-

Bronchitis

ally non-productive, whereas in chronic bronchitis it becomes painless and associated with copious and easily expectorated mucoid or mucopurulent sputum. One of the most painful types of cough is that associated with acute pleurisy. This is a short and dry cough and usually occasioned by a change of position or deep breathing; it is particularly common in the early stages of pneumonia when the pleura is involved. *Pleurisy*

In pulmonary emphysema the cough is associated with a marked degree of dyspnoea and is non-productive. It may be paroxysmal and simulate that associated with asthma. It is of the greatest importance when dealing with emphysema and bronchitis to assess the value of the pulmonary signs which are giving rise to the cough, since it is well known that those two conditions often mask a tuberculous lesion. *Emphysema*

The cough of tuberculosis is modified according as it is or is not associated with bronchitis or emphysema. Any cough that persists for a long time must raise the suspicion of tuberculous infection. In the early stages of pulmonary tuberculosis the cough is dry and non-productive. Sputum is an indication that ulceration of the lung has taken place. The cough naturally varies with the complications of the disease; for example, if a secondary infection has taken place in the lungs the cough may become less distressing to the patient, but at the same time may be tiring in its frequency and troublesome from the abundant and frequent expectoration. When a laryngeal lesion accompanies the lung condition, the cough often becomes painful and is associated, as in simple laryngitis, with hoarseness or even aphonia. When tuberculous disease has advanced to the state of cavitation, the cough is apt to become paroxysmal, as the patient attempts to empty the cavity. This type of paroxysmal cough occurs in advanced bronchiectasis, and here the explanation of its production is the same as in tuberculous cavity. *Tuberculosis*

In new growth of the lungs there is almost always cough. It may be due either to associated bronchitis or to pressure exerted upon a bronchus. In the early stages it is dry and hacking, but later tends to be associated with expectoration; the sputum is often blood-stained or even definitely haemorrhagic. *Tumours*

In extensive fibrosis of the lungs, due either to tuberculosis or some chronic inflammatory condition, cough always occurs, and the patient usually states that it is of long standing. The cough is generally accompanied by expectoration and not infrequently by small haemoptyses. *Fibrosis*

The cough which is brought about by effort on the part of the patient, if not painful like the cough in pleurisy, is usually an indication of heart failure. This symptom may be present before any marked degree of dyspnoea occurs. *Heart failure*

(3)—Pressure on the Respiratory Tract

The chief conditions which cause this type of cough are enlarged mediastinal glands, mediastinal new growths, and aneurysm. Enlargement of mediastinal glands is a not uncommon cause of cough in *Enlarged mediastinal glands*

children. The cough is apt to be paroxysmal when the glands press upon the larger air-passages. Such a condition has often been mistaken for whooping cough. If, however, the mediastinal glands are enlarged, but not sufficiently to exert any marked degree of pressure, the resulting cough is mild but irritating, persistent, and non-productive. In a young child such a cough, either in its mild or paroxysmal form, should lead to search for further evidence of enlarged mediastinal glands.

*New growths
and
aneurysm*

When a main bronchus or the trachea is pressed upon by a large mass of glands as in lymphadenoma, by a mediastinal new growth, or by an aneurysm, the so-called brassy cough occurs. The truly brassy cough is almost always diagnostic of some severe degree of pressure.

(4)—Reflex Causes

Apart from those respiratory diseases which produce cough reflexly, 'reflex coughs' occur in children as a result of local irritation in the ears or teeth. There is very little characteristic in cough of this type and its diagnosis is usually made by excluding pulmonary or other causes; the diagnosis is confirmed and the cough disappears after the appropriate treatment has been given to the source of irritation. The cough is usually dry, persistent, and not associated with expectoration. It is seldom that a patient suffering from such a cough is brought on that account to the doctor; it is usually the condition of the ear or mouth which claims the first attention.

*Stomach
cough*

The common reflex cough in adults is usually attributed to dyspepsia and, as already mentioned, is coexistent with pharyngitis. The typical sufferer from this reflex cough is in the habit of disturbing his gastric functions at night by indiscretions in food and drink, and is rewarded the next morning with pharyngeal irritation and a distressing cough. This cough is often alarming in severity and relieved only when large and copious expectoration takes place. The cough is typically a morning cough and tends to disappear during the day.

It is doubtful if the old belief is true that any irritation of the vagus will cause cough. Irritation of the stomach has been supposed to produce cough through the agency of the vagus, but it is significant that operations performed under local anaesthesia of the abdominal wall only, in which there must be considerable irritation of this nerve, are rarely if ever attended by cough. Stomach cough is a popular diagnosis especially in children; but, though occasionally the true explanation, it is a dangerous diagnosis to make as many such coughs have been proved later to be due to pulmonary tuberculosis or even to pulmonary neoplasm. Stomach cough is usually the diagnosis made when no abnormal physical signs have been found in the respiratory system. A more careful search in the respiratory organs should diminish the frequency of this diagnosis.

There are, however, instances of cough in which no satisfactory explanation of the cause is forthcoming. Abnormal physical signs in the respiratory tract are totally absent, and suspicion of gastric irrita-

tion or pharyngeal irritation from smoking or alcoholism is not warranted. Such coughs are often the cause of much anxiety. In many cases they are examples of habit cough and are reflexes, the result of a past irritation. Thus a man who from excessive smoking has developed a troublesome cough may finally give up smoking, but for months afterwards the cough persists; the habit has become so well established that the inclination to cough is irresistible. The only way of treating such a cough is to persuade the patient to exert self-control to overcome the habit. *Habit cough*

(5)—Nervous Causes

The nervous cough is usually of a barking nature and is more distressing to others than to the patient. It is non-productive and is generally associated with some other cause, however slight. In most cases other nervous elements predominate and it is to these rather than to the respiratory symptom that treatment should be directed. This type of cough is common at about the time of puberty.

Still more harassing is the hysterical cough; this may be very alarming, and unless the possibility is in mind may, especially when associated with haemoptysis, lead to the erroneous diagnosis of some severe pulmonary condition. The cough is often produced through a desire for sympathy and, if this is not evoked in sufficient measure, tends to get worse, till sooner or later it produces the desired response. I have known one case in which an apparently alarming and distressing cough having failed to produce a sufficiently sympathetic response, the patient one morning had a considerable haemoptysis; subsequent haemoptyses occurred which later were found to have been self-inflicted by scratching the back of the throat with a needle. When the patient knew that he had been found out the cough disappeared. *Hysterical cough*

In this type of cough, as in others, the essential cause is often shown by the results of treatment.

3.—DIAGNOSIS

The practitioner must be acquainted with the numerous causes of cough, and must realize that it is a symptom which may denote anything from mere nervousness up to such grave conditions as pulmonary new growth or aneurysm. It should never be regarded lightly, for even cases with a considerable nervous element may have a graver underlying cause. It is thus very important to consider carefully and in detail all the information imparted by the patient regarding the type and character of his cough. Such points as the following should be borne in mind: Is it a morning cough? Does it become less frequent and less troublesome as the day goes on? Is it influenced by changes of weather or climate? Does it occur chiefly or only if the patient is recumbent? Is it productive or unproductive? Is it associated with the expulsion

of sputum or not? If sputum is associated with it, how is it produced and what is it like? Does it come up freely or after great effort? Is it frothy, mucoid, or tenacious; is it small or abundant in amount? What is its colour, and particularly, is it, or has it at any time been, blood-stained? Does the cough occur in paroxysms? Is it brassy? Is it painful? All these factors are of paramount importance and without their full consideration the physician is not likely to arrive at the true cause.

Any part of the respiratory tract is sensitive, but the relative sensitivity of the parts varies. For example, a foreign body in the upper respiratory tract sets up irritation and causes coughing; irritation by secretion in the bronchial tubes, or by touching the lung as may happen when, in exploration of the chest, the needle penetrates too far, is likely to produce a fit of coughing. The pleura is definitely sensitive, and, unless it has been previously anaesthetized, tapping a chest may precipitate a fit of coughing as the needle passes through the parietal layer.

4.—TREATMENT

The indiscriminate use of cough mixture is often harmful, as it may tend to mask the underlying cause. Many patients are content for months or even years to keep their coughs in check by some soothing cough mixture, only to discover in the end that they have advanced pulmonary disease which, detected earlier, might have yielded to treatment.

A cough due to enlarged tonsils and adenoids must be treated by removal of the cause. If the symptom is attributed to a long uvula this may be cut, but there is a danger in making this diagnosis before other causes have been excluded. For the pharyngitis which is often associated with dyspeptic conditions the best treatment is to remedy the latter, prescribing a suitable diet and limiting the allowance of alcohol and tobacco.

*Laryngitis
and
tracheitis*

In laryngitis and tracheitis, relief can usually be obtained by a mixture designed to lessen congestion of the inflamed mucous membrane and promote secretion, and thus to lessen the pain of the cough. Such a mixture as the following is of value:

Sodium bicarbonate	—	—	—	—	15 grains
Tincture of ipecacuanha	—	—	—	—	7½ minims
Syrup of tolu	—	—	—	—	30 minims
Syrup of squill	—	—	—	—	30 minims
Spirit of chloroform	—	—	—	—	10 minims
Infusion of senega	—	—	—	—	to 1 fl. ounce

Dose: One fluid ounce every four hours until the sputum has become free.

For these conditions inhalations are also useful, of which 60 minims of compound tincture of benzoin added to 1 pint of hot water is an

example. The addition of menthol and oil of eucalyptus, as in the following, sometimes helps:

Compound tincture of benzoin	—	—	7 fl. drachms
Menthol	—	—	30 grains
Oil of eucalyptus	—	—	30 minims

Add 60 minims to one pint of hot water.

Another remedy which is of value for relieving the cough of laryngitis and tracheitis is the application round the neck of kaolin poultice B.P. (or the proprietary antiphlogistine), or warm olive oil.

In the early stages of bronchitis, when the cough is troublesome, painful, and non-productive, the same mixture as recommended for laryngitis may be used with benefit. The following mixture is also useful: *Early stages of bronchitis*

Antimonial wine B.P.C.	—	—	15 minims
Ammonium chloride	—	—	10 grains
Spirit of chloroform	—	—	10 minims
Syrup of orange	—	—	60 minims
Camphor water	—	—	to 1 fl. ounce

This should be discontinued, probably after two or three days, when the sputum becomes free.

The cough in the later stages of bronchitis, when expectoration is copious, calls for a mixture such as the following: *Late stages of bronchitis*

Ammonium carbonate	—	—	5 grains
Tincture of nux vomica	—	—	8 minims
Tincture of squill	—	—	15 minims
Distilled water	—	—	to 1 fl. ounce

or alternatively:

Ammonium carbonate	—	—	5 grains
Tincture of squill	—	—	15 minims
Camphorated tincture of opium	—	—	20 minims
Infusion of senega	—	—	to 1 fl. ounce

A very useful prescription for children suffering from a cough which is just becoming loose is the following:

Tincture of ipecacuanha	—	—	2 to 5 minims
Camphorated tincture of opium	—	—	5 to 10 minims
Potassium nitrate	—	—	2 grains
Oxymel	—	—	30 to 60 minims
Distilled water	—	—	to 2 fl. drachms

The treatment of the cough of pulmonary tuberculosis will depend upon whether it is of a useful or useless type. If the latter, the patient can often be trained to suppress the act, but it is often necessary to *Pulmonary tuberculosis*

prescribe some sedative drug, especially when the useless cough prevents sleep. Such a mixture as the following is worth a trial:

Diamorphine hydrochloride	—	—	$\frac{1}{12}$ grain
Syrup of wild cherry	—	—	30 minims
Syrup of codeine phosphate B.P.C.	—	—	30 minims
Distilled water	—	—	to 4 fl. drachms

Or the following prescription may be found even better:

Diamorphine hydrochloride	—	—	$\frac{1}{12}$ grain
Codeine	—	—	$\frac{1}{8}$ grain
Dilute sulphuric acid	—	—	2 minims
Glycerin	—	—	10 minims
Syrup of tolu	—	—	to 1 fl. drachm

For this type of cough non-aqueous inhalations are often helpful, and for this purpose the most useful drugs are creosote, menthol, and alcohol (90 per cent) in the following proportions:

Menthol	—	—	60 minims
Creosote	—	—	60 minims
Alcohol (90 per cent)	—	—	240 minims

A few drops sprinkled on a mask and inhaled for a few minutes have often a soothing effect.

If the cough is useful, ammonium chloride and antimonial wine are invaluable. The prescription already detailed for the early stages of bronchitis may be used.

*Fibrosis of
the lungs*

In fibrosis of the lung, due either to pulmonary tuberculosis or other causes, the cough is usually associated with well-marked dyspnoea and often is in great part caused by failure of the right ventricle of the heart. Relief will therefore be better obtained from cardiac tonics, such as digitalis and nux vomica, than from sedative cough mixtures. Some such prescription as the following is in common use:

Tincture of digitalis	—	—	5 minims
Ammonium carbonate	—	—	5 grains
Tincture of nux vomica	—	—	5 minims
Spirit of chloroform	—	—	10 minims
Distilled water	—	—	to 1 fl. ounce

In some severe cases Nativelle's digitaline granules $\frac{1}{800}$ grain, two or three times a day, may reduce the cough.

Belladonna is of definite use when an anti-spasmodic effect is desired. The following prescription is an example:

Tincture of sumbul B.P.C.	—	—	15 minims
Tincture of stramonium	—	—	10 minims
Tincture of belladonna	—	—	5 minims
Spirit of chloroform	—	—	15 minims
Distilled water	—	—	to 4 fl. drachms

Further measures for treatment of cough are discussed under the titles to which reference is directed on p. 441. In any given case the measures adopted must depend upon the diagnosis.

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COW-POX

See SMALLPOX

COXA VARA

See JOINTS: DISEASES AND DISORDERS

CRAMP

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Reference may also be made to the following titles:

ABDOMINAL PAIN	CONVULSIONS IN
ARTERIAL DISEASE AND	INFANCY
DEGENERATION	MUSCLE DISEASES
ASTHMA	RABIES

1.—INVOLUNTARY MUSCLE SPASMS

(1)—Definition

266.] Cramp may be defined as a painful muscular contraction which *Epilepsy* cannot be relaxed at will. There are many morbid states in which cramps are frequent and disturbing but in which they are neither prominent nor necessary symptoms, for example, peripheral neuritis, diabetes mellitus, food poisoning, and cholera. In other states of disease muscular spasms of this kind provide the entire or the essential symptomatology, as in heat-cramp, occupational cramp, tetany, strychnine poisoning, and tetanus intoxication.

As defined above, the term cramp includes many states of muscular contraction which are not strictly cramps as ordinarily understood; but although their discussion in detail is not necessary here, their brief consideration assists an understanding of the causes of cramp. The nature of the spasm in each case, as well as the other symptoms which commonly accompany it, usually leaves no doubt as to its site of origin.

Excitation of the contractile fibres in the skeletal musculature can be brought about voluntarily, or involuntarily and reflexly, by changes determined in any of the neuro-muscular mechanisms included in the brain, the spinal cord, and the peripheral motor system; and hence it follows that muscular spasms which are incapable of voluntary relaxation may result from a suitable pathological change at any of these levels.

(2)—Pathogenesis

(a) *The Motor Cortex*

Many epileptic seizures result in motor convulsions which are involuntary spasms of the musculature. When they occur while consciousness is retained, the patient cannot inhibit or relax them voluntarily, and they may be moderately painful. Their cerebral origin can usually be readily recognized, but when they take the form of repeated muscular contractions, limited always to one limb (focal or Jacksonian epilepsy), and are not followed by any impairment of voluntary movement, their nature may at first be obscure and it may be difficult with certainty to distinguish them from cramps of peripheral origin.

(b) *The Basal Ganglia*

Disease of this part of the brain provides many varieties of voluntary

muscle spasm. Few are painful and most are associated with other symptoms sufficiently obvious to leave no doubt about the origin of the spasms themselves.

*Paralysis
agitans*

The muscular rigidity of paralysis agitans is included, in terms of the above definition, as a persistent cramp, since it cannot be abolished by voluntary effort, and in the later stages severe aching pains may occur in the rigid limbs. The involuntary muscular spasms of athetosis, increased by voluntary effort and uncontrollable by intent, are not painful; they involve so much of the musculature at one time that they are not commonly thought of in terms of cramp.

Athetosis

*Epidemic
encephalitis*

Among the various bizarre motor disturbances shown by patients who have previously suffered from epidemic encephalitis, involuntary muscle spasms are common. A torticollis, persistent or intermittent, a persistent contracture of the calf muscles which prevents the heel from resting on the ground when walking, and spasms of the eye muscles (oculogyric crisis) are common examples; they may give rise to considerable discomfort but rarely to pain.

(c) *The Lower Motor Neurones*

Myoclonus

Sudden brief repetitive contractions of a muscle, or of a group of muscles, affecting certain muscles more than others, and sometimes symmetrically placed muscles on the two sides of the body, are described as myoclonus (paramyoclonus multiplex). These spasms are very rarely painful; they disappear during sleep and are abolished by contraction of the affected muscles but they cannot otherwise be inhibited by voluntary effort.

Neuritis

Many forms of peripheral neuritis produce muscle cramp as a prominent and disturbing symptom. Alcoholic neuritis, arsenical neuritis, and poisoning with chemical substances, such as acriflavine, are examples.

(d) *The Neuro-Muscular Junction and the Muscle Fibre*

There are two forms of painful muscular contraction which are known to originate at this level: the cramps of tetany, and those which follow repeated muscular contractions during circulatory arrest. Tetanic convulsions are muscular cramps in the strictest sense of the word. The pain which arises in the second of these conditions is not in most cases associated with a hardening or shortening of the muscle itself but it may increase to intolerable severity and is in all other respects a symptom of muscle cramp.

2.—CONDITIONS IN WHICH CRAMP IS THE ESSENTIAL SYMPTOM

(1)—Heat-Cramp

Definition

This term is applied to the painful muscle-spasms which follow muscular activity in a high environmental temperature. The symptoms

have all been well recognized in certain industrial centres since 1878. Observed first in miners, they have since then been the subject of many commentaries and of much research among workers in iron mills, and in furnace rooms on board ship and on land.

In suitable circumstances heat-cramp is common; in some places its incidence is as high as that of heat-stroke and in the furnace rooms of some factories most of the men employed have mild or severe heat-cramp once each summer. The working temperatures above which heat-cramp is likely to occur are generally over 100° F.: for example, for working on the Boulder Dam 110° F., for ship stokers 112° F., and for Pullman-car chefs as high as 150° F. Even though the furnace-room temperature is uniformly high throughout the year the seasonal incidence is nevertheless well-marked, and 90 per cent of the cases are observed in the summer months: thus a high atmospheric as well as a high working temperature is important. Compared with the high atmospheric temperature of the summer months, the relative humidity plays little or no part. *Aetiology*

Although the condition is well recognized in places as far apart as the coal mines in England, the gold mines in South Africa, and the sugar-cane fields in Australia, the condition appears to be almost entirely unknown in some countries, for example, in Germany and France. It is therefore an occupational disease among those working in surroundings with a high average temperature, and appears most often under certain well-defined geographical and climatic conditions. *Geographical distribution*

Intercurrent diseases appear to play but little part in increasing the susceptibility to heat-cramps. Chronic alcoholism has not any disposing effect, but the gastro-intestinal disturbance associated with a bout of acute alcoholism is often a decisive determining factor because of the loss of fluid by vomiting. Poor general hygiene and recent inadequately treated mild attacks of cramp are both important disposing causes. *Disposing factors*

Since there are many more cases during the first few days after the surrounding temperature has begun to rise than later in the summer, adaptation seems to play an important part in lessening the susceptibility to cramp. This is probably due to the production by the sweat glands of a more copious secretion with a lower chloride content.

The first symptom is usually a severe and painful muscle-spasm while at work, but occasionally there is a prodromal period of vertigo, headaches, and muscle twitchings. Alternatively, the initial cramp may appear an hour or two after returning home from the day's work, or up to eighteen hours after work has ceased. *Clinical picture*

The spasms often affect first the flexors of the fingers, but sometimes muscles of the pelvic girdle or those of the abdominal wall; they may spread from one muscle group to others or appear in many groups simultaneously; they recur every few minutes and last from one to three minutes each, relaxing gradually; they may be precipitated by any external stimulation, as by mechanical jarring or by a draught, and may be preceded by a few irregular twitchings of the muscles about to *Spasms*

become spasmodically contracted; they gradually become less frequent and disappear with a few milder spasms at intervals increasing up to half an hour.

Each spasm may be accompanied by sweating and contraction of the pupils, but seldom by vomiting. During cramp the muscles feel as hard as stone; the pain is agonizing but ceases completely and immediately when the muscle relaxes. The muscles most affected are those most actively employed during work. The involuntary muscles have never been found to be involved. There is usually profuse sweating before and during the attack of cramp.

*Changes in
the blood*

The condition is regularly associated with certain striking changes in the blood and in the renal functions. The blood shows an increase in serum protein (chiefly in globulin) and in cell volume, such as is observed elsewhere only in the most severe cases of cholera. The diminution in the serum sodium and the increase in the potassium, phosphates and calcium are also extreme. Some polymorphonuclear leucocytosis regularly occurs. The blood-sugar is unaffected but the percentage oxygen saturation is usually low.

*Changes in
the urine*

In spite of the tissue dehydration and the profuse sweating anuria is not observed; the pH of the urine at the beginning of cramp is often as low as 5.0, but the titratable acid is not increased; the chlorides are always much diminished and even negligible in amount for one to three days; phosphaturia and creatinuria are often found; an increase in the total nitrogen occurs and its amount is roughly in proportion to the severity of the cramps.

*Probable
explanation of
heat-cramps*

Experimental investigations show that neither a simple direct rise of the body temperature nor a disturbance of carbohydrate metabolism provides an explanation of heat-cramps. The clinical and chemical changes suggest that they are due to the lowering of the sodium and chloride in the serum which results from loss in the sweat without adequate replacement: the cramps occur when these substances decrease to a critical level which is itself a function of individual susceptibility, of acclimatization, and of intensity of work.

*Differential
diagnosis*

The differential diagnosis of the condition entails its distinction from heat-stroke, from nocturnal cramps, and from convulsive seizures. Its occurrence in the earliest days of a heat-wave, and the absence of any considerable rise in the body temperature and of delirium, serve to distinguish it from heat- or sun-stroke. Nocturnal cramps occurring in a person susceptible to heat-cramp should be regarded and treated as heat-cramp. Careful examination never fails to reveal the correct origin of cerebral convulsions.

Prophylaxis

The prevention of heat-cramps entails certain general measures and one specific prophylactic. A state of general good health supervised by frequent physical examinations, good food, and restful sleep are the only important general measures. In addition, during the first few days of a heat-wave or of a change from cool to hotter working conditions, activity should be restricted and only gradually increased. The specific

prophylactic is sodium chloride. The disadvantage of providing this in exceptional quantities with meals is that the appetite may be disturbed and the ingestion is unreliable; the disadvantage of ordering salt tablets to be taken separately is that they may not be taken regularly. The most satisfactory way to increase the salt intake is to provide a 0.1 per cent sodium chloride solution as the only drinking water available; this has no perceptible salty taste when cool and it allays rather than promotes thirst.

The treatment of heat-cramps is by rest in bed and weak saline drinks *Treatment* for all mild cases. For severe cases 600 to 1,000 c.c. of physiological saline should be injected intravenously during the first six hours and thereafter repeated if the patient is still dehydrated. Morphine in doses up to $\frac{3}{4}$ grain does not stop the cramp or ease the pain; hot packs may give very transitory relief in mild cases; dextrose, which has often been advocated, probably acts only by virtue of the saline solution in which it is administered. With the above saline treatment patients are usually relieved of cramp before the first intravenous injection has been completed.

(2)—Occupational Cramps

In some persons who are called upon to carry out precisely co-ordinated movements repeatedly, in rapid succession, for long periods, there develops in the muscles thus employed a state of cramp which at first makes difficult, and which eventually may altogether prevent, the execution of these particular movements. Persons employed in a clerical capacity which entails much handwriting (scriveners), telegraphists who are repeatedly depressing a contact key, gold-beaters, tailors, watch-makers, and those who play some musical instrument, provide the largest number of examples of this form of disability. *Aetiology*

When repeated acts, such as writing by hand, tapping a key, hammering gold-leaf, are concerned, it is found in the earliest stage that after any one of them has been carried out for a long time without intermission, their execution becomes clumsy; for example, handwriting becomes cramped and scrawled, and hammering irregularly spaced. If the condition gets worse it is found that the disturbance appears after fewer repetitions and becomes more quickly disabling; in severe cases almost the first effort to carry out the act in question is frustrated by the inco-ordination which develops. *Clinical picture*

These changes are accompanied whenever they appear by a stiffening of the muscles—at first of those most over-exercised in the acts concerned, later of neighbouring muscles, and finally of all the muscles of the limb. This persistent contraction of the muscles is invariably uncomfortable and is often severely painful. In some cases it is associated with a tremor of the limbs involved.

Although the cramp may disturb or altogether prevent the use of the affected limb for the particular act the repetition of which had led to the symptom, it does not, even in the severest cases, produce a

similar disturbance in other movements of the limb. Moreover their appearance is determined by the attempt to repeat the particular act in a particular way, i.e. it is not the production of the act itself but the way of executing it which is all-important. Thus, for example, a scrivener who has become quite unable to produce more than a few written words with his pen held in his accustomed manner may still be able to write currently with his pen held otherwise or with his arm in some quite different position, i.e. it is not the act of writing but the use of the hand and forearm muscles in writing that is the provocative factor. It does in some cases happen that if some other method of writing is adopted this quite rapidly becomes impossible for exactly the same reason, and the disabling spasm may appear even when some mechanized alternative for writing, such as typewriting, is substituted for it.

*Relation of
condition to
occupational
neurosis*

This condition is usually referred to as an occupational neurosis, the assumption being that an emotional disturbance is its essential cause. In support of this view it is pointed out that the persons affected frequently show other behaviour anomalies which are clearly neurotic, that the limb remains fully serviceable for all unrelated, even though precisely adjusted, actions and that, since the disability in most cases threatens the livelihood of its victims, a state of anxiety must be expected.

Although this view is in many cases still further supported by the beneficial results of psychotherapy, it is not necessarily correct for all. The post-encephalitic state is one which provides many examples of a precisely similar disturbance of motor functions, caused in these cases by structural changes in the basal ganglia. Torticollis, various bizarre abnormalities of movement as well as involuntary movements, are all commonly observed to occur upon a background of disorganization of the learned skilled movement-sequences, such as are entailed in walking, fastening a button, and washing the face. Moreover it is also a common observation that one form of repetitive activity, e.g. walking, may be grossly disturbed while another form, running, which employs the same muscles may remain comparatively unimpaired.

Since these similar effects are known to follow *structural* changes in the basal ganglia, it must be allowed that a *functional* disturbance of these motor centres may be the immediate cause of cramp even in cases in which some underlying emotional disorder is clearly present. In other cases it is possible that changes akin to fatigue are set up in the basal ganglia which are inherently susceptible to them, and that the anxiety factors called into play are secondary in their appearance to a threatened or to an already established motor disability.

Treatment

When a patient complains that some form of movement necessary for his occupation is becoming difficult owing to cramp, it is essential to make certain that this disturbance is not due to incipient organic disease such as progressive muscular atrophy or paralysis agitans. If organic changes are present it is clearly desirable that the patient should be encouraged to persevere, with modification or simple reduction of the day's work, for as long as his disease allows. On the other hand,

Rest

if such structural damage can be excluded it is equally important to insist upon a period of complete rest from the practice of the movements in question. For young persons of unstable temperament in whom this disability has appeared it is in fact often preferable to urge a permanent change to some different occupation. The duration of the rest, which will vary from two to three weeks to several months, will depend upon the degree of severity already reached by the disability, upon the nature of the treatment to be undertaken, and upon the emotional state of the patient: if the patient can be meanwhile kept in continuous employment in some other capacity, much will be gained.

The importance which the practitioner attaches to underlying disturbances of the patient's emotional life will determine the lines along which active treatment is to be given. If after full investigation it is decided that the disability is maintained as a response to some emotional difficulties, then an attempt must be made to help the patient to understand that this is so and to achieve a better psychological adjustment, i.e. one which does not entail the exhibition of this particular symptom. At the same time attention should be directed to the limb in which the symptom has appeared. Very light massage to this, combined with the practice of free, swinging movements in which the muscles are kept as slack as possible, should be used, but exercises in which the muscles are tensed or used against resistance must be entirely avoided. Electrical stimulation of the whole limb in a warm bath by weak surging galvanic currents is also useful in some cases.

*Psychological
treatment*

*Local
treatment*

In some forms of occupational cramp the movements disturbed can only be carried out in one way or with one form of implement, but in some cases of writer's cramp, re-education, to throw as much of the work as is possible upon the muscles of the shoulder girdle and upper arm and as little as possible upon the small hand-muscles, may be of decisive importance in getting the patient back to work and in keeping him there. The substitution of some different form of pen or the recommendation to write in some unusual position is never permanently useful.

Re-education

(3)—Intermittent Claudication

This term, borrowed originally from veterinary surgery, is used to describe a condition of lameness with pain in the legs which develops after a short period of exercise in patients in whom obstructive arterial disease is the commonly present pathological change (see Vol. II, p. 48). The condition is found also in patients suffering from severe anaemia in whom arterial disease is neither suspected nor evident. It is known to follow any local disease or injury which causes obstruction of the arteries to the leg. When the condition develops without any of these causes present it is found more often in Jewish subjects and has been attributed to excessive tobacco smoking but without any clear justification.

Definition

Aetiology

*Clinical
picture*

Such patients complain that after walking—particularly in the open air—for a comparatively short distance, they are brought to a standstill by severe pain in the legs. With rest the pain gradually abates and they are able to resume walking after an interval of several minutes. In general the longer the rest the further they can walk without a return of the pain. This trouble may appear first in one leg at a stage in which the other leg is still normal, but eventually both legs are in most cases disturbed in a similar manner.

Examination before the patient has exercised his legs usually shows impairment or absence of palpable pulsation in the anterior and posterior tibial arteries of the leg; in severe cases this reduction in the pulse may be obvious also in the popliteal or even in the femoral arteries. The extremity is habitually cold and slightly cyanotic—the blueness is deeper when the leg is dependent than when it is supported in the horizontal position. Necrotic changes in the toes may lead to the heaping-up of dead skin directly beneath the nails.

After exercise has been brought to an arrest by the severity of the pain which has developed, the muscles in which the pain is felt are tender on pressure and the skin of the leg is deeply cyanosed and often mottled. The muscles may be hard and bunched-up but such spasm appears not to be essential to the development of lameness or pain. The pain itself is described as continuous and aching; it disappears completely after the limbs have been rested for an interval which commonly varies from fifteen to sixty seconds.

(4)—Tetany

Definition

This is a condition of localized muscular cramps which appears as a feature of many different states of disease, in each of which either a diminution in the blood-calcium or alkalosis occurs. One or the other of these two factors is therefore considered as responsible for the tetany; since marked alkalosis leads to diminution in the ionized calcium in the blood it is possible that this last change is primarily responsible in every case.

*Changes in
blood-
calcium*

The normal blood-calcium of 9 to 11 mgm. per 100 c.c. is commonly reduced to 6 mgm. per 100 c.c. when tetany of mild degree occurs. After damage or removal of the parathyroid glands the blood-calcium may fall from the normal 10 mgm. per cent to 4 mgm. per cent and fatal tetany ensue.

*Clinical
picture*

The muscle cramps are often preceded by a sensation of tingling in the hands and feet. Spasm of the small muscles of these then occurs: the fingers and thumb are extended and adducted and the wrist flexed: the toes are flexed and the feet 'pointed'. In more severe cases the arms are firmly flexed and adducted and the legs fully extended and crossed in adductor spasm. The jaw, face, and neck muscles stiffen with trismus, a risus sardonicus, and extension of the head, and the back may be hyperextended in opisthotonos. This muscle cramp, when more than mild, is painful. Subcutaneous motor nerves become hyperexcitable to

pressure so that spasm of the interossei muscles of the hand may follow pressure on the ulnar nerve behind the elbow, and spasm of the facial muscle a tap over the parotid gland. Stiffness of the fingers may persist between individual cramps. The laryngeal muscles may by their spasmodic contraction cause prolonged inspiratory dyspnoea—laryngismus stridulus. This condition yields to treatment with calcium lactate by mouth, or calcium chloride or calcium gluconate intravenously. Parathyroid extract (parathormone) is commonly used in all persistent cases (see CONVULSIONS IN INFANCY AND CHILDHOOD, and PARATHYROID GLANDS, DISEASES OF).

(5)—Tetanus Intoxication

This results from the action upon the nervous system of an exotoxin *Pathogeny* of *B. tetani*. The bacillus gains entry into the body usually through some accidentally caused surface wound; the toxin reaches the central nervous system via the perineural lymphatics. Its effects are exerted first upon the cells of the spinal grey matter. After local inoculation in this way the organism is not spread through the blood-stream, hence invasion of the nervous system at different levels is by spread of the toxin itself within the nervous system from its first point of entry.

The effect of the toxin may be summarized as leading to hyperexcitability and disorganization of all local muscular reflexes; at first only local, and later even remote, stimuli throw all neighbouring muscles into violent cramp; reciprocal inhibition of antagonistic muscles does not occur and the whole limb becomes rigidly fixed.

These muscle cramps, which appear on an average about a week after inoculation with the bacillus, may be noticed first in the muscles around the infected wound, and next in other parts of the same limb, before spreading to involve the entire musculature of the body. When the central nervous system is more diffusely attacked no such directional spread occurs and the first sign of cramp may appear in the muscles of the face and jaw.

Violent cramps, severely painful, become superimposed upon a background of persistent muscular rigidity; they occur spontaneously but are also in severe cases provoked by any stimulation of the patient, so that all nursing or feeding attention results in a convulsive spasm which throws the body into opisthotonos. Cramp of the laryngeal and respiratory muscles may give rise to anoxaemia and dyspnoea.

The condition is treated by the use of the specific antiserum and also *Treatment* by intramuscular, intravenous, or intrathecal injections of magnesium sulphate—a substance which is believed to act directly on the muscles and which causes muscular relaxation and, in larger doses, paralysis. The use of curare in doses of $\frac{1}{16}$ to $\frac{1}{2}$ grain intramuscularly has been advocated.

(6)—Strychnine Poisoning

This results in paroxysmal muscular spasms which become completely generalized when they are severe. A single dose of $\frac{1}{3}$ grain strychnine

chloride may give mild spasms, a dose of $\frac{1}{2}$ grain will invariably result in repeated violent attacks, and a dose of 1 grain is usually fatal.

The convulsive muscular cramps appear spontaneously but are also precipitated by almost any stimulation. The musculature of the trunk and face is as much affected as is that of the limbs: the jaw is clenched, the face distorted, the respiratory movements arrested, the limbs stiffen in extension or in flexion, and the trunk may be strongly arched in opisthotonos. Between these violent spasms the muscles have no residual stiffening and normal voluntary movements are possible. The cramps are severely painful and exhausting.

(7)—Rabies (Hydrophobia)

*Clinical
picture*

This results from infection with an ultramicroscopic neuropathic virus which is transmitted to man by the bite of an animal whose saliva is infected, and which spreads inside the body via the peripheral nerves. After an invasion period attended by pains, depression, and insomnia, muscular cramps appear often first in the pharyngeal muscles—causing dysphagia and provoked by any attempt to swallow—later in the muscles of respiration, and finally in all the muscles of the body with violent convulsive seizure and opisthotonos. These cramps are at all times occasioned by attempts to drink and often also by the sound of water or even the thought of drinking (see RABIES).

(8)—Myotonia

Definition

The name myotonia describes a tendency for the muscles taking part in a voluntary or in a reflex movement to remain fixed in a state of contraction from which they can only gradually be voluntarily relaxed or passively stretched. When it affects the forearm muscles, the grasp cannot be relaxed at will; when it affects the face, a smile becomes fixed and only slowly fades and the eyelids after firm closure can only gradually be opened; when it affects the legs, these become temporarily rigid so that they cannot be flexed, or temporarily fixed in flexion so that they cannot be extended. The disability lessens on any one occasion with continued use of a muscle, so that after repeated contractions relaxation becomes normally rapid. This symptom always gives more trouble in cold weather. With the disturbance of voluntary activity there is usually an increase of the irritability of the muscle to percussion, so that a blow on the muscle gives a persistent hardening and shortening of the particular muscle fibres hit (mechanical myotonia) and there is a similar persistence of the contraction produced by electrical stimulation.

Pathogenesis

Although this symptom can in many ways be most satisfactorily regarded as due to a failure of adaptation of the muscle fibre, such as may be experimentally induced to some extent by a shortage of calcium, when it appears in the course of a naturally occurring disease there is no evidence to support the view that there is in fact any lowering of calcium concentration in the blood or muscle. As myotonia appears in

susceptible subjects after the nervous connexions of the muscles with the central nervous system have been functionally interrupted with novocain, its appearance cannot be due essentially to the anterior-horn cells continuing to fire off impulses after their activity in response to voluntary effort has ceased. On the other hand the motor nerves do continue to carry impulses from the spinal cord down to the muscles while these are myotonically contracted after voluntary effort has ceased—impulses which are probably set up reflexly in the spinal cord by afferent stimulation from the tonically contracted muscles.

This muscle spasm cannot be cut short by any effort of will and is therefore a form of cramp, but although often uncomfortable, it is rarely painful.

3.—CONDITIONS IN WHICH CRAMP IS AN OCCASIONAL SYMPTOM

Consideration of the foregoing description of diseases in which cramp is the main symptom leads to the belief that it may be expected when any one of the following conditions is present: a lowered blood-calcium, much depletion of the sodium chloride content of the body, or the presence of some factor which increases the excitability of the lower motor neurones.

An attempt to catalogue all those other disease-states in which cramp is liable to arise as an incidental symptom is bound to be incomplete, and in itself without interest or significance. However, the occurrence of cramp in many of these conditions can be reasonably regarded as due to one or another of the above changes, although its occurrence in others still remains without any satisfactory explanation.

In severe cholera the stage of purgation and vomiting usually leads to severe cramps in the legs, abdomen, and back; occasionally the whole skeletal musculature may be affected and all the muscles bunched, hard, and extremely painful. These cramps outlast the stage of evacuation and persist during the general collapse which succeeds it. In this disease it is usually attributed to the loss of chlorides in the vomit and a consequent diminution of the blood chloride. *Cholera*

The cramp which occurs in children or adults with pyloric stenosis or with high intestinal obstruction associated with much vomiting is ascribed to the same cause. In steatorrhoea associated with sprue, or with tuberculous enteritis, or occurring 'idiopathically', the cramps commonly observed can be explained as due either to the loss of calcium combined as soaps or to the diminished absorption of vitamin D. *Intestinal disease*

In rickets the blood-calcium is sometimes lowered and the vitamin D available is always diminished: in osteomalacia and in hunger osteopathy the calcium is always pathogenically low in the diet: in these three conditions also cramps are common. *Rickets*

- Pregnancy and lactation* During pregnancy and lactation the drain on the blood-calcium is greatly increased and in susceptible subjects a mild variety of tetany with cramp is found.
- Alkalosis* It is commonly affirmed that the state of alkalosis induces cramp although it has not been clearly indicated by what means an increase in the pH of the blood brings about such muscular spasms. Following hyperpnoea, or loss of hydrochloric acid after repeated vomiting, or after an overdose of alkalis such as sodium bicarbonate, muscle cramps may occur. It is possible, but unlikely, that since the state of alkalosis causes a reduction, not in the total but in the ionized calcium of the blood, it leads to cramp by virtue of this effect.
- Uraemia* In uraemia cramps are common: there is sometimes a slightly lowered blood-calcium but more often also an alkalosis.
- Diabetes insipidus* Diabetes insipidus may lead to cramps owing to loss of chlorides, and the muscle spasms which sometimes appear after an injection of pituitary (posterior lobe) extract may be due to the same cause.
- Neuritis* In all cases of multiple peripheral neuritis in which the sensory neurones are severely affected, causing spontaneous pains, hyperalgesia of the skin and tenderness of the muscles, painful cramps are apt to occur in the extremities. These find a ready explanation in terms of local irritation of the peripheral neurones—sensory and motor.
- Other conditions* Milder cramps are also described in the course of toxic goitre, and of diabetic and hypoglycaemic attacks—in these conditions without any obvious explanation.

4.—THE MECHANISM OF CRAMP

Cramp having been defined as a state of painful spasm of the muscles, it is natural to infer that the pain and the spasm are probably due one to the other. Two possibilities arise. The pain may be due to the violence or to the unnatural distribution of the tension developed in the muscle fibres; on the other hand the spasm of the muscle may be induced and may persist on account of the over-excitation of local reflexes due to painful stimuli arising in the course of some disease.

Thus the spasm of muscles around a damaged joint or those appearing in the course of a painful peripheral neuritis may at first appear to have as their sufficient cause a local reflex hyperexcitability due to constant over-activity of pain afferents. Similarly the pain felt in the muscles in occupational cramp or in heat-cramp seems at first sight adequately accounted for in terms of the tension developed in the muscles involved.

Further examination, however, shows that in many cases there is no such causal relation between persistent spasm of a muscle and the pain felt in it, and that an exactly similar pain may be experienced in a muscle which does not become spasmodically contracted.

In discussing the mechanism of cramp there are therefore two factors

to be dealt with separately, namely, the changes which give rise to the persistent shortening or hardening of the muscles and those which are responsible for the pain.

(1)—The Changes responsible for the Muscular Contraction

The distribution of muscular spasms usually provides a sufficient indication of their site of origin. A hemiplegic distribution points clearly to the opposite side of the brain, to the motor cortex or to the basal ganglia as containing the centre of disturbance underlying the spasms, epileptic or striatal, which are observed.

In nearly all cases here considered the cramps are widely and irregularly distributed and until it is definitely known that the biochemical changes causing them are such as operate upon this or upon that structure, no conclusion can be reached about the mechanism through which the spasmodic contraction of the muscle fibre is initiated or maintained.

There is no satisfactory evidence that deficiency of sodium chloride can give rise to hyperexcitability and persistent over-activity of the lower motor neurone, of the neuro-muscular junction tissue, or of the muscle fibre: in any case it seems more likely that the sodium chloride deficiency is only an indication of more widespread disturbances of salt metabolism and that it is not a lessening in the amount of this particular salt but an associated change in the amount of potassium or of some other base which is immediately responsible for these neuro-muscular symptoms.

Biochemical theories

It has been shown that the cramps of tetany can be abolished by curare: this suggests that the immediate effects of calcium deficiency are produced not in the muscle fibre but upon some mechanism at, or central to, the neuro-muscular junction, but even here more precise localization is not yet possible.

Thus, except in special instances it is not possible to name with any degree of certainty the mechanism immediately responsible for the former of the two essential factors involved in cramp as here defined—the muscle spasm. In spite of much work which has recently been carried out in investigating the mechanism responsible for the latter factor—the pain—this also remains largely a matter of surmise with certain clearly defined indications in given cases.

(2)—The Changes responsible for the Pain

When a muscle becomes spasmodically contracted and at the same time painful it is at first sight reasonable to suppose that the pain felt is caused by the contracted state of the muscle fibres. Further consideration throws doubt upon the correctness of this view in many cases. In most, the amount of pain is disproportionately severe when compared with the tension developed in the muscle. A cramped muscle which is severely painful can often be passively extended by the patient himself or by someone else, yet a strong voluntary contraction of the

Muscle tension and pain

same muscle which cannot be passively stretched by the exertion of much greater force may be entirely painless.

It is for this reason certain that it cannot be the total tension developed by the muscle which causes the pain. Therefore the mechanical forces produced within the cramped muscle by its state of contraction, if they are to produce pain, must be distributed in a manner different from that present during a voluntary contraction.

Excessive stretching and pain

It has been suggested that the pain is produced by excessive stretching of muscle fibres, not themselves contracted, by those which are spasmodically shortened, but this is unlikely because there are excellent reasons for concluding that in a given muscle the most vigorous contraction that can be voluntarily produced does not at any one moment throw into contraction more than a proportion of its individual fibres. Yet in this case the fibres at the moment relaxed are not passively stretched or constricted to a degree which gives rise to pain.

Distribution of activity in muscles

It follows that a simple stretching or constriction of relaxed parts of the muscle cannot account for the pain of cramp. Such mechanical effects can only be expected to give rise to pain if the patterning or distribution of activity in the muscles in cramp is quite other than that during a voluntary contraction. There are reasons for believing that this is in fact the case. It is commonly found that when a muscle is stimulated to contract by electrical excitation applied over its motor point or over its motor nerve—remote from the muscle—the contraction which results is painful with an intensity of stimulation which falls definitely short of that required to produce a contraction of force at all comparable with that which results from a maximal voluntary effort. It might in that case be supposed that such a contraction is painful because the electrical discharges are exciting simultaneously both the motor neurones to the muscle and the muscle afferents on their way up from the muscle to the spinal cord. This explanation is not acceptable since it is found in such cases that if, during painful electrical tetanization of a muscle, a strong voluntary contraction of the same muscle is carried out the pain is not increased and is usually lessened.

Therefore it seems probable that at least one cause of the pain in cramp is to be found in an abnormal distribution of the excited contractile elements in the muscle. It is noteworthy that those involuntary movements and muscle spasms which result from disordered activity at higher levels of the nervous system, although often extremely powerful in their mechanical effect, are rarely if ever severely painful, whereas those movements and spasms which result from changes at the lowest motor levels are frequently very painful although their mechanical effect may be at the same time comparatively small. This is explicable if the patterning of activity within the muscle is an affair of the lowest motor centres in the cord, in which case involuntary movements which result from abnormal activity at higher levels will be finally mediated through these lowest levels which are themselves intact.

The further possibility remains that the pain of cramp may accom-

pany the muscular contraction as an associated effect proceeding from the same cause.

When the blood-supply to a limb is arrested and its muscles are exercised by repeated voluntary contractions, this exercise is in all cases brought to a standstill by the severity of the pain which arises after an interval which depends upon the rate and force of work done. The recent work of Lewis and others has shown that ischaemia of an exercised limb results in pain partly by virtue of the anoxaemia and partly by virtue of the circulatory arrest. There is a very close similarity between the nature, the distribution, and the duration of pain in this ischaemic exercise and that which arises in patients in whom the circulation of the limbs is defective as the result of disease (intermittent claudication), or in whom the oxygen supply to the limbs is inadequate (anaemia).

*Effect of
ischaemia*

Both in the arrest of exercise in an experimentally ischaemic limb and in the paralytic lameness which develops clinically in intermittent claudication and anaemia, the pain, of intolerable severity, is not accompanied by any comparable contracture of the muscles: in the ischaemic limb they become tender but not bunched-up or hard, and in the states of claudication hardening of the muscles, although often observed, is not invariable.

For these and for similar reasons Lewis concluded that every muscular contraction brings normally into existence some factor which he has called the pain-producing or P factor and that this is normally removed during the recovery phase of contraction by some process for which a sufficient supply of oxygen is essential. During rapidly repeated contractions under normal conditions some of this P factor may fail to be removed by oxidation owing to the shortening of the recovery period, and it is then diluted or washed away by the circulation. According to this view repetitive muscular contractions under anoxaemic conditions become painful because the P factor is not destroyed. With a reduction in the rate of circulation through the limb this P factor accumulates without being sufficiently rapidly diluted or removed. This factor may be an actual substance produced as a by-product of muscular contraction, and it is conceivable that when cramps are painful it is because the agency which is causing them favours its formation during contraction, or inhibits its destruction during recovery or its removal by the circulation.

5.—VISCERAL CRAMP

(1)—Definition

The foregoing examples of cramp all occur in the skeletal musculature normally under voluntary control. There are many conditions in which spasmodic contraction of visceral muscle is associated with pain but in few is it possible to observe directly the muscular contraction which is painful. The outstanding example of cramp as here defined is provided by the contractions of the pregnant uterus in labour. In this

*Cramp in
involuntary
muscles*

process, with each of the recurring pains a hardening of the uterus can be felt through the abdominal wall. The only difference between these contractions and the painful spasms of skeletal muscle is that the latter are invariably pathological in that they result from a transitory or persistent disturbance of the normal working conditions, whereas the uterine contractions are physiological in their occurrence. Why this normal process of parturition should be almost invariably so painful is difficult to explain: in all save the fact that they are physiological, uterine contractions can claim to be regarded as visceral cramp.

*Angina
pectoris
compared
with cramp*

Angina pectoris is a symptom-complex which has commonly been explained as due to cramp of the heart muscle. Lewis called attention to many points of close similarity between the pain of this condition and that of intermittent claudication and has produced conclusive evidence that it is due not to a state of persistent spasm or cramp of any part of the heart but to a factor identical with that operative in claudication. That the onset of pain in angina pectoris is sudden appears at first sight to invalidate this conclusion; but this apparent difference is explained by Lewis as due to the fact that since the heart is in constant repetitive activity, the amount of the pain-producing or P factor which results from successive contractions is disposed of by the circulating blood at a rate which keeps it even in normal circumstances only just below the threshold for the production of pain. A sudden impairment of the blood-supply to the cardiac muscle will, if this be true, result in an accumulation of the P factor which so quickly becomes supraliminal that the pain is felt almost simultaneously.

Therefore the term cramp can only be applied to angina pectoris if it is understood to imply the occurrence of pain of a type similar to that felt in skeletal muscle cramp but without any evidence of spasmodic contraction of the cardiac muscle.

(2)—Colic

The musculature of the alimentary tract, when working normally, contracts isotonically, producing a movement of the contents of the stomach or intestines without any but the slightest increase in tension. In a healthy person this normal activity is carried on without arousing any sensation: when resistance is encountered to the normal movement of its contents, contraction of the muscle fibres gives rise to an increase of tension in the intestinal wall and pain is felt. This pain is usually intermittent and has the 'gripping' quality of colic. Only in some cases does each spasm of pain correspond clearly with a contraction of the intestinal musculature which can be directly seen or felt. In some cases a firm knotting of a segment of the intestine can be felt simultaneously with the pain. With the visible peristalsis that can be seen in dilated coils of intestine through a thin abdominal wall, pain is uncommon. In some cases in which the intestinal contents have been rendered radio-opaque it is possible, by screening the patient, to view a recurrent spasm of some part of the bowel narrowing the shadow cast by its

contents: in these cases it is occasionally found that the patient complains of pain which appears, persists, and disappears simultaneously with this spasm.

That this pain is referred to some part of the abdominal wall is well known: the manner in which it is so referred is imperfectly understood and the manner in which it is caused simultaneously with the increase of tension in the gut wall is completely obscure. It is permissible to explain this as due to the formation of some factor akin to, or identical with, that believed to be formed in skeletal muscle only if it can be shown that the circumstances which give rise to spasm of the musculature give rise also to interference with its blood-supply. Of this there is no evidence and nothing to suggest that it is likely. *Referred pain*

It was pointed out above that the chief difficulty in explaining the pain of skeletal muscle cramp as due to the contraction of the muscle is that voluntary contractions of much greater force are painless. Since voluntary contraction of the gut musculature does not occur, this difficulty does not arise to prevent an explanation of colic as due directly to the increase of tension in the intestinal walls. There is, however, nothing to suggest whether the actual site of origin of the pain-producing afferent impulses is the muscle fibre or the interstitial tissues. *Possible causes of pain*

It was further suggested that the pain of skeletal muscle cramp might be causally associated with a disturbance of the normal distribution or patterning of activated fibres within the spasmodically contracted muscle. One of the most potent stimuli to the contraction of any hollow viscus is an increase of tension in its wall such as is produced by its experimental distension. It therefore seems probable that if the normal motor activity of the intestine meets anywhere with a resistance which leads to an increase of tension, this will tend to be still further raised by the spasmodic local contraction which it induces and which will disorganize the normal distribution of contracting and relaxing muscle fibres. Therefore the pain of abdominal colic also may perhaps be associated primarily with a disturbance of the normal distribution of excitation among the muscle fibres of the intestinal wall.

Biliary and renal colics probably arise in much the same way in association with similarly abnormal states of contraction of the muscle fibres in the biliary and urinary passages. *Biliary and renal colics*

(3)—Asthma

This condition is probably due to spasm of the muscle fibres around the smaller bronchioles. Although an asthmatic attack may lead to distressing discomfort in the chest, no pain comparable with that of skeletal muscle cramp or of intestinal colic occurs. With recent work on the innervation of the bronchial muscle fibre, and bronchoscopic observations of their activity, knowledge of the normal working of this part of the body has been considerably advanced, but it is not yet possible to state with certainty which part of this neuromuscular

system is abnormally excited by the various allergic and nervous factors which give rise to the asthmatic attack.

(4)—Spasm of the Arteries

Spasmodic contraction of a single artery has been seen to occur in the retina through the ophthalmoscope. The temporal artery lying between the scalp and the skull has been observed in a state of contraction during attacks of migraine, and arteries immediately beneath the skin have been felt to be temporarily contracted into firm narrow cords in several other conditions.

In none of these states of arterial spasm is there any pain that can be ascribed to the abnormal state of contraction of the fibres in these blood-vessel walls. A large number of conditions, from epilepsy and migraine to Raynaud's disease, have been variously ascribed to arterial spasm but in most cases with little or no justification.

(5)—Conclusion

The term visceral cramp should therefore be used with much more reserve than has commonly been the case. Muscle cramp as here defined occurs in the uterus, where its aetiology alone distinguishes it from that of the skeletal muscles, and in those viscera the musculature of which is designed to provide movements of their contents by relatively isotonic contractions.

The latter case is similar in its aetiology to skeletal cramp but may differ in that the mechanisms whereby pain is aroused in the two cases may not be identical.

In all cases the occurrence of pain appears to be associated more constantly with circumstances calculated to disturb the normal distribution of excitation within the muscle than with any other alteration of the working conditions.

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CRANIAL NERVE AFFECTIONS

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Reference may also be made to the following titles:

ATAXY	BRAIN: VASCULAR
BELL'S PARALYSIS	DISORDERS
BRAIN ABSCESS	DEAFNESS
BRAIN: REGIONAL	DIPLOPIA
DIAGNOSIS	DISSEMINATED SCLEROSIS
BRAIN TUMOUR	HERPES
	NEURALGIA

1.—THE OLFACTORY NERVE

267.] The function of this nerve and its central connexions is the appreciation of flavours, and therefore anosmia or loss of the sense of smell impairs what is popularly called the sense of taste, the latter sense being in fact confined to the appreciation of salt, sweet, bitter, and sour. Disease of the olfactory nerve is uncommon, and defect or loss of smell is usually associated with local disease in the nose. It is of interest that the olfactory nerve filaments act as the channel of access of the virus of poliomyelitis from the nasopharynx into the nervous system.

Head injuries associated with concussion may, from damage to the olfactory nerve filaments as they traverse the cribriform plate, be followed by temporary or, more frequently, by permanent loss of smell. Further, a tumour on the under surface of the frontal lobe may compress one olfactory bulb or tract and thus lead to unilateral anosmia. It has been said that such pressure from an intracranial tumour, or raised intracranial tension from a tumour anywhere within the skull, may lead to a sense of irritation in the nose which makes the patient rub this organ continually. This is a rare symptom and of little diagnostic value.

Causes of injury and symptoms

The sense of smell is best tested by the use of such familiar odours as those of cloves, peppermint, or asafetida.

2.—THE OPTIC NERVE

268.] The optic nerve in its course from the back of the eyeball to the optic chiasma is exposed to pressure from intra-orbital tumours and from tumours in the neighbourhood of the sella turcica (pituitary adenoma, pituitary-stalk tumour). It may also be the seat of vascular lesions (thrombosis of the central vein, embolism of the central artery), or of inflammatory or degenerative processes. Fractures through the orbit may crush the nerve, and at the same time so damage the ophthalmic artery as to interfere with the retinal blood-supply.

Causes of injury

A complete interruption of conduction leads to total blindness and to dilatation and immobility of the pupil. At first the appearance of the disc may be normal but in a few weeks the characteristic pallor of primary optic atrophy develops. With incomplete lesions there may be a limitation of the field of vision. Thus, pressure upon the nasal side of the nerve by a pituitary tumour leads to restriction of the temporal field of vision and usually ends in a temporal hemianopia.

Symptoms

Primary optic atrophy may be caused by pressure upon the nerve or by degenerative or inflammatory lesions within it. In tabes dorsalis, for example, both the latter processes are operative and there is some gummatous infiltration of the nerve and also primary degenerative changes in the nerve fibres. Retrobulbar neuritis, which will be referred

Primary optic atrophy

to below, also leads to some atrophy of the nerve. This primary atrophy is seen ophthalmoscopically as an increasing pallor of the optic disc which may become quite white, or may develop a greyish colour. The edges stand out in strong contrast to the rest of the fundus oculi and the lamina cribrosa is well seen. The retinal vessels may show no change. In retrobulbar neuritis, the pallor may be confined to a limited area of the disc.

Papilloedema In conditions of abnormally raised intracranial tension, such as are associated with intracranial tumour or abscess, a venous stasis occurs in the optic nerve head and optic disc. The pressure of cerebrospinal fluid in the subarachnoid space surrounding the optic nerve is, in these circumstances, sufficient to compress the central vein as it leaves the optic nerve and traverses the space on its way to the cavernous sinus.

As the venous stasis of the nerve head develops, the optic disc begins to swell, its edges lose their definition, the disc itself becomes red, the physiological pit is filled up and the condition known as 'choked disc' develops. The vessels as they pass peripherally across the disc may be hidden in the swelling. The veins are engorged, and flame-shaped haemorrhages appear on the fundus outside the disc. White patches of exudate also make their appearance. If the oedema extends outwards to the retina, the latter may be thrown into folds between the disc and the fovea. On the summit of these folds small spots of white exudate appear and the so-called 'macular fan' is formed. The swelling thus produced may reach a height of from four to six dioptries. As this process increases, vision begins to be impaired and total blindness may ensue if steps are not taken to relieve the intracranial hypertension. The failure of vision may be gradual, but in some cases it is sudden and complete.

Secondary optic atrophy Secondary, or consecutive optic atrophy, is the natural sequel of papilloedema when this does not subside in time to prevent atrophic changes from developing in the optic nerve. The swelling gradually diminishes, the disc becomes white and striated in appearance, but the lamina cribrosa does not re-appear since the physiological pit remains filled with exudate. The vessels may also remain partly surrounded and obscured by exudate as they lie on the disc. The disc edges do not regain their pristine clearness, and the final appearance of the disc is that of a dense white, featureless, and hazy-edged circle. Whether or not there is restoration of vision as swelling subsides depends upon the damage sustained by the optic nerve fibres, but frequently total blindness is the sequel of an unrelieved papilloedema.

Retrobulbar neuritis Certain poisons, such as tobacco and methyl alcohol, may lead to the condition of retrobulbar neuritis and attack the macular bundle of fibres in the optic nerve. This may also occur in diabetes but by far the commonest variety of this condition is associated with disseminated sclerosis. It is often stated that chronic infection of the nasal sinuses may lead to this lesion of the optic nerve, but the frequency with which this factor can be clearly determined has been grossly overrated, and there can be little doubt that in most instances in which it is invoked

the case is in fact one of early disseminated sclerosis. In some cases no aetiological factor is ever discovered.

Since the macular bundle in the nerve is prone to bear the brunt of the process, the characteristic defect of vision is a central scotoma. This is the nature of the so-called 'tobacco amblyopia'. But in methyl alcohol ('wood alcohol') poisoning and in diabetes complete and permanent blindness may ensue, whereas in disseminated sclerosis the whole visual field may be affected and vision become uniformly hazy. In tobacco amblyopia recovery is the rule if tobacco be given up; in disseminated sclerosis an almost complete restoration of visual acuity is also the rule though recurrences may lead to spoiling of the sight; total or permanent blindness does not ensue in this disease.

Disseminated sclerosis is unquestionably the most common cause of retrobulbar neuritis, and the patch of demyelination in one or both optic nerves may be the first manifestation of the disease. In some instances it antedates all other signs by several years. In such cases, of course, the proof that this disease is in question is not obtainable at the time, and only the appearance later of other signs confirms the nature of the retrobulbar neuritis. In these circumstances, vision rapidly fails during the course of a few days, remains misty for two or three weeks and then clears again. Some few weeks after recovery the first signs of pallor of the affected disc make their appearance.

The belief, formerly widespread, that focal sepsis in the nose and its accessory sinuses was responsible for the optic nerve lesion led in the past to various nasal operations, and the natural recovery of vision lent an illusory confirmation to this false aetiological view. Now that the preponderant role of disseminated sclerosis in causing retrobulbar neuritis is becoming generally recognized, it may be hoped that futile procedures of this kind will become increasingly rare.

Pallor of the optic disc and slight impairment of visual acuity are the final evidences of an old retrobulbar neuritis, and they are found in very many cases of disseminated sclerosis in its later stages.

3.—THE THIRD, FOURTH, AND SIXTH NERVES

269.] These nerves arise from an elongated column of cells in the mid-brain and pons. The third nerve nucleus lies in the ventral part of the peri-aqueductal grey matter, and immediately caudal to it lies the fourth nerve nucleus. The nucleus of the sixth nerve lies more caudally in the pons beneath the floor of the fourth ventricle at its anterior end. It is, of course, not continuous with the third and fourth nerve nuclei. The fibres of the third nerve pass ventrally, traverse the red nucleus and emerge on the ventral surface of the brain at the anterior end of the pons. Those of the sixth nerve emerge at the junction of the pons and medulla, and those of the fourth nerve pass dorsally, decussate, and emerge on the dorsal aspect of the brain-stem.

*Origin of
nerves*

*Distribution
of nerves*

The third nerve supplies the internal, superior, and inferior rectus muscles, and also the inferior oblique and levator palpebrae superioris. It is generally stated that this nucleus, or the part of it known as the Westphal-Edinger nucleus, supplies the ciliary muscle and sphincter pupillae; but this is probably not the case and it may be more accurate to say that the fibres to these muscles travel with the third nerve in its peripheral course, their origin being uncertain.

The fourth nerve supplies the superior oblique, and the sixth the external rectus muscles.

After their emergence from the brain-stem the third and sixth nerves pass forwards to the outer side of the clinoid processes, then in the outer wall of the cavernous sinus, and finally into the orbit.

The sixth nerve has the longer course which is angulated as it crosses the apex of the petrous bone. The fourth nerve passes laterally round the cerebral peduncle to reach the outer side of the posterior clinoid process whence its course is similar to that of the third and sixth nerves.

*Ocular
paralyses*

Just as in the case of the limb muscles we distinguish paralysis of upper and of lower motor neurone type, so in the case of ocular movements we must divide their disorders into comparable categories. There are paralyses of movements from lesions of supranuclear centres, and paralyses of muscles from nuclear or infranuclear lesions. Of the former, paralysis of conjugate deviation or of upward deviation of the eyes are examples; of the latter, we have paralysis of one or more ocular muscles from a lesion involving either the nucleus or the nerve fibres in their brain-stem or peripheral course. In the former type the affection is bilateral and, since the eyes maintain their association, there is neither squint nor diplopia, but in the latter the eyes commonly do not act together and squint and diplopia ensue. These various disorders of ocular movement may now be considered in sequence.

(1)—Paralysis of Ocular Muscles*Symptoms*

Weakness or paralysis of an ocular muscle causes defective movement of the eye, whence follows a non-correspondence of the two visual axes, that is, strabismus or squint, double vision or diplopia, and erroneous projection of the image seen with the squinting eye. The squint is the result not only of the failure of the weak muscle to effect a normal excursion of the eye, but also of a compensatory overaction of the opposite eye. This so-called secondary deviation of the normal eye is due to the great voluntary effort made to swing the other eye over to the desired position. Another result of the defective excursion of the affected eye is erroneous projection of the image. The abnormally great effort to innervate the weak muscle corresponds to a wider excursion of the affected eye than actually occurs, and suggests to the subject that the object seen is further removed from the mid-position than in fact it is. This erroneous projection is maximal when the squinting eye is used alone.

Paralysis of the external rectus. The affected eye does not move outwards, there is convergent squint and uncrossed diplopia, the two images being vertical and parallel. *Paralysis of individual muscles*

Paralysis of the internal rectus. The affected eye does not move inwards, there is divergent squint, crossed diplopia, the two images being vertical and parallel.

Paralysis of the superior rectus. Movement is defective upwards and also outwards. There is a crossed diplopia on looking upwards, the false image being at a higher level than the true and slightly oblique.

Paralysis of the inferior rectus. Movement is defective downwards and outwards. There is a crossed diplopia below the horizontal, the false image being lower than the true and slightly oblique.

Paralysis of the superior oblique. There is defect of movement downwards and inwards. There is uncrossed diplopia below the horizontal, the false image being oblique.

Paralysis of the inferior oblique. There is defect of movement upwards and inwards, with diplopia on looking up and inwards. The diplopia is uncrossed and the false image oblique.

When paralysis of a single muscle occurs, it is almost invariably of the external rectus, the muscle supplied by the sixth nerve.

(2)—Paralysis of the Third, Fourth, and Sixth Nerves

In a complete lesion of the third nerve the external rectus and superior oblique muscles only remain active. The eye can be moved only outwards and slightly downwards and inwards. The levator palpebrae superioris, the sphincter iridis, and the ciliary muscle are also involved. The upper eyelid falls completely and cannot be raised, the pupil is moderately dilated and immobile, and there is paralysis of accommodation. Some compensatory overaction of the frontalis muscle may be present by way of an attempt to counteract the ptosis. Partial lesions of the nerve may occur, in which the various muscles are unequally affected. *Paralysis of third nerve*

Paralysis of the fourth nerve is very rare apart from associated paralysis of other nerves. There is diplopia on looking below the horizontal and the head may be held inclined downwards and to the affected side. *Of fourth nerve*

Paralysis of the sixth nerve is not uncommonly an isolated condition, and its signs are those of paralysis of the external rectus muscle. *Of sixth nerve*

(3)—Paralysis of the Intrinsic Ocular Muscles

These muscles include the sphincter iridis which is innervated by fibres which travel with the third nerve, the dilatator pupillae which is innervated by the sympathetic, and the ciliary muscle innervated through the third nerve.

The iris has three actions, namely, reflex contraction of the pupil to light, reflex dilatation of the pupil to cutaneous stimulation, and contraction of the pupil and of the ciliary muscle on accommodation.

In paralysis of accommodation (cycloplegia) near vision is blurred but *Cycloplegia*

distant vision is normal unless the patient is hypermetropic. There may or may not be an associated failure of the pupil to contract.

Iridoplegia

In paralysis of the pupil (iridoplegia) the pupil may be abnormally dilated from paralysis of the sphincter (mydriasis), or unduly small from spasm of the sphincter, or paralysis of the dilatator (miosis). It is probable that the miosis of tabes dorsalis which accompanies the loss of the light reaction (Argyll Robertson phenomenon) may in part be due to atrophic changes in the structure of the iris itself, for in the final stages of tabes it is not uncommon for the pupil to become immobile as well as extremely small. Reflex iridoplegia, or loss of the light reflex, is the essential component of the Argyll Robertson phenomenon. It is important when testing the reaction to light to employ a strong, even illumination. The seat of the lesion in this condition is not certainly known and remains a matter of discussion, some holding that it is central and situated in the peri-aqueductal grey matter, others that it is peripheral and in the neighbourhood of the ciliary ganglion or nerves. In lesions involving the cervical sympathetic, the pupil on the affected side is smaller than its fellow and from weakness of the levator palpebrae superioris the palpebral fissure is smaller than normal. It is stated that true enophthalmos is also present, but this is doubtful.

(4)—Lesions of Nerve Fibres within the Brain-Stem

Paralysis due to lesions of the nerve fibres within the brain-stem can usually be identified by the presence of other signs indicating the seat of the lesion. Examples of these are:

Weber's syndrome

Weber's Syndrome. The lesion is in the ventral part of the mid-brain and the signs consist in third nerve palsy on the side of the lesion and hemiplegia of the opposite side of the body.

Benedikt's syndrome

Benedikt's Syndrome. The lesion is in the dorsal (tegmental) part of the mid-brain, and the signs consist in homolateral third nerve palsy and crossed tremor due to involvement of the red nucleus.

Millard-Gubler syndrome

Millard-Gubler Syndrome. The lesion is in the pons, and the signs are paralysis of the external rectus muscle (with internal squint) and of the facial muscles on the side of the lesion with crossed hemiplegia.

Foville's syndrome

Foville's Syndrome. If the lesion involves the sixth nerve nucleus there may be paralysis of conjugate deviation of the eyes to the side of the lesion.

(5)—Conjugate Ocular Paralysis

Paralysis of conjugate deviation

These belong to the category of paralysees of movements and not of one or more muscles. Paralysis of conjugate deviation to the side is the commonest of this group, and is due to a lesion in the region of the sixth nerve nucleus in the pons. If there be loss of conjugate deviation to the right, the left internal rectus is inactive when this movement is attempted, but acts normally on convergence. The lesion probably interrupts association fibres between the sixth and third nerve nuclei and therefore lies between these nuclei.

Paralysis of upward movement of both eyes is sometimes seen, the lesion in this case being in the region of the anterior corpora quadrigemina. Clinically, tumours of the pineal body may by compression of the tegmentum of the mid-brain produce this form of conjugate paralysis. *Paralysis of upward movement*

(6)—Supranuclear Paralyzes

In this comparatively rare form of disorder of ocular movement, the eyes may fail to move in response to certain kinds of stimuli, but not to others. Normally, ocular movements are under the predominant influence of impulses from the auditory and visual regions of the cerebral cortex. In this form of paralysis the response to one or other of these stimuli may be lost. Thus the subject may be unable to deviate his eyes to order, but can do so in response to labyrinthine stimuli.

(7)—Inco-ordination of Ocular Movements

The various lesions and pathological processes which produce ataxy or inco-ordination of movements of the limbs and trunk rarely produce any effect upon the external ocular muscles, which enjoy a remarkable immunity in this respect. Thus in athetosis, chorea, and in the tremor of paralysis agitans ocular movements remain intact. But in cerebellar disease ocular movements do not escape, and show as their characteristic defect the phenomenon known as nystagmus. This is a rhythmical jerking movement of the eyes, usually in the horizontal plane, which appears occasionally when the eyes are at rest (congenital nystagmus) but usually on conjugate deviation to the side. This movement varies in amplitude and speed. In unilateral cerebellar lesions (e.g. tumour or abscess) there is a slow, ample nystagmus on looking to the side of the lesion, and a rapid, fine nystagmus on looking away from the side of the lesion. Sometimes the former is replaced by a definite defect in conjugate deviation to the side of the lesion, the eyes tending to swing back to the mid-position before deviation is complete. The other circumstances in which nystagmus may appear are fully dealt with in the article under that title (see also ATAXY, Vol. II, p. 202). *Nystagmus*

(8)—Aetiology of Ocular Paralyzes

Ocular paralyzes may be due to lesions of the nerves in their peripheral course (either within the skull or in the orbit) or, in their course through the brain-stem, to lesions of their nuclei or of supranuclear mechanisms. Of these, peripheral lesions are the most commonly seen. They may be caused by injury to the skull involving the orbit or the middle fossa. In these circumstances inequality of the pupils is common, but gross ocular palsies are relatively infrequent and when present are transient. In this connexion it is of interest that oedema of the orbit following head injury may lead to mechanical difficulty in eye movement and thus to transient squint and diplopia when no lesion of the nerves is present.

Neurosyphilis is a frequent cause of ocular palsies, either by means of a gummatous basal meningitis involving the sheaths of the nerves, or, *Neurosyphilis*

in tabes, from nuclear degeneration. The third and sixth nerves are those usually affected.

Lepto-meningitis Acute leptomeningitis may also lead to the development of ocular palsy.

Subarachnoid haemorrhage In subarachnoid haemorrhage transient weakness of one or more ocular muscles may occur from the presence of blood in the basal cisterns.

Neuritis In multiple neuritis ocular palsies may ensue. Thus in diphtheritic paralysis there may be paralysis of accommodation, or transient paralysis of the third nerve. In this case the lesion is nuclear.

Diabetes mellitus In diabetes ocular paralysis sometimes occurs, but the seat of the lesion is not certainly known.

Exposure to cold It is sometimes held that an isolated third or sixth nerve palsy may be produced by exposure to cold, in the way that appears frequent in the case of Bell's palsy of the face. How this can happen is not clear, but it is certain that sudden palsies of one or other of these nerves may occur in otherwise healthy persons. Their onset may be accompanied by pain in the eye and they last for some two or three months before disappearing again. In elderly persons with high blood-pressure such isolated palsies are thought to be due to the pressure of an atheromatous internal carotid artery upon the nerves as they lie in the outer wall of the cavernous sinus.

Intracranial tumour In cases of intracranial tumour any of the oculomotor nerves may be involved either directly by the growth, or indirectly as a result of the raised intracranial tension. Sixth nerve palsy is not infrequent in these circumstances and forms a 'false localizing sign'.

Gradenigo's syndrome Gradenigo's syndrome is the name applied to the combination of severe neuralgic pain on one side of the head with an external rectus palsy. It is found in association with otitis media and is thought to be due to a local meningitis over the tip of the petrous bone.

Central lesions Central lesions of the oculomotor nuclei occur in a number of circumstances. In disseminated sclerosis, epidemic encephalitis, and poliomyelitis ocular palsies may occur.

Chronic nuclear ophthalmoplegia In the condition known as chronic nuclear ophthalmoplegia there is a slowly developing external, and then internal ophthalmoplegia, the pupils becoming fixed and the eyes immobile. The lesion is a degeneration of the nerve nuclei of unknown aetiology.

4.—THE FIFTH NERVE

270.] The fifth or trigeminal nerve is the largest cranial nerve. It has both motor and sensory roots. The roots emerge from the ventro-lateral aspect of the pons in a sheath of dura mater (cavum Meckelii) on the tip of the petrous bone. The large sensory root enters the Gasserian ganglion here, and, emerging from it, divides into the ophthalmic, maxillary, and mandibular divisions.

The small motor root innervates the masseter, temporal, tensor palati, and tensor tympani muscles and the anterior belly of the digastric. The ophthalmic division enters the orbit to innervate the eye, the lacrimal gland, the meninges, the mucous membrane of the nose and eyelids, and the skin of the nose, upper eyelid and frontal part of the scalp. The maxillary division (and the sphenopalatine ganglion) innervate the skin of the cheek and fore part of the temple, the lower eyelid and the side of the nose and the upper lip, and the upper teeth, the mucous membrane of the nose, the antrum, the posterior ethmoidal cells, the tonsil and the roof of the mouth. The mandibular division innervates the skin of the side of the head, the pinna and external auditory meatus, the skin of the lower lip and lower part of the face, the mucous membrane of the mouth and tongue, the lower teeth and gums, the salivary glands, the temporo-mandibular joint, and part of the Eustachian tube.

*Distribution
of fifth nerve*

Loss of sensation and paraesthesiae within the distribution of the root are the signs of a lesion of the sensory portion of the nerve. Loss of the corneal reflex may be regarded as the minimal indication of such a lesion, and is often seen as such in cases of tumour of the auditory nerve, where the fifth nerve is stretched and compressed by the growing tumour. Gross lesions of this kind rarely lead to severe pain in the distribution of the nerve, but usually to subjective numbness. The insensitive half of the tongue may become furred, the normal half remaining clear.

*Symptomatology of
lesions
Sensory root*

Lesions of the motor root cause weakness and wasting of the masseter and temporal muscles. The wasting is visible and the weakness leads to deviation of the jaw towards the paralysed side when the mouth is opened, and inability to make grinding movements, that is, lateral movements, of the jaws. The paralysis of the pterygoid muscles is responsible for this. Signs of defective action of the other muscles supplied by this root are not easily detected.

Motor root

The length of this nerve and its branches exposes it to inflammatory and compressing lesions in its intracranial and extracranial course, and its extensive central connexions in the brain-stem also lead to its involvement in vascular and other lesions of the brain in this region.

*Aetiology of
fifth nerve
lesions*

Trigeminal neuralgia is discussed under the title NEURALGIA, GLOSSOPHARYNGEAL AND TRIGEMINAL.

5.—THE SEVENTH NERVE

271.] The nucleus of the seventh or facial nerve lies deep in the lateral portion of the pons. Its fibres pass dorsally and mesially to circle round the sixth nerve nucleus. They then turn ventrally and emerge from the brain-stem at the lower end of the pons. The nerve innervates the facial muscles, including the platysma, and the stapedius. Associated with it is the nervus intermedius of Wrisberg. This is an afferent nerve whose cells of origin lie in the geniculate ganglion which is attached to the trunk of the facial nerve as this traverses the Fallopiian canal in the petrous bone. The peripheral fibres of this nerve pass into the chorda

*Distribution
of seventh
nerve*

tympani with which they are distributed to the anterior two-thirds of the tongue, supplying the gustatory end-organs. The central fibres join the afferent fibres of the glossopharyngeal nerve (which innervates the taste end-organs of the posterior third of the tongue) and both groups of taste fibres end in the fasciculus solitarius in the pons.

On emerging from the brain, the facial nerve passes with the fifth nerve across the lateral recess of the posterior fossa of the skull to enter the internal auditory meatus. Here it is joined by the nervus intermedius and both then traverse the Fallopian canal. The chorda tympani leaves this before the stylomastoid foramen is reached, but the facial nerve emerges from this foramen and breaks up into its terminal branches which are distributed to the facial muscles.

*Aetiology of
facial nerve
lesions*

The nerve may be involved in pathological processes at any point of its course from its origin in the pons to its peripheral passage through the parotid gland. Central lesions may be inflammatory (poliomyelitis, epidemic encephalitis), neoplastic, or vascular. In poliomyelitis a transient facial palsy may be the only paralytic manifestation. Pontine tumours usually involve neighbouring structures, such as the sixth nerve nucleus or fibres, producing a unilateral sixth and seventh paralysis. A more extensive lesion may involve the long paths which traverse the pons. Thus in Foville's syndrome, usually due to thrombosis of a branch of the basilar artery, the signs are homolateral sixth and seventh nerve palsies, with paralysis of conjugate deviation to the side of the lesion and crossed hemiparesis.

In its course after emergence from the brain-stem, the nerve may be stretched and compressed by a tumour of the eighth nerve in the lateral recess. This compression is shown by slight weakness of the face, and rarely by irregular clonic spasms of the face. The nerve may also be involved in a parotid tumour. The commonest mode of involvement of the nerve, however, is that known as Bell's palsy (see Vol. II, p. 307).

*Facial hemi-
spasm*

Facial hemispasm is a malady which commonly affects elderly persons, women more often than men. Its aetiology is unknown. The muscles of one half of the face enter into irregular clonic spasm which fluctuates in severity but tends to persist indefinitely. Facial weakness does not ensue.

The treatment of facial spasm is very unsatisfactory. It may be mitigated in severity by the administration of sedatives, and for this purpose the continuous use of bromides is not advised, since many elderly persons tolerate them badly and become heavy and even stuporous. Phenobarbitone (luminal) in $\frac{1}{2}$ grain doses twice or thrice daily may be tried, gentle massage is sometimes useful, but electrical stimulation tends to aggravate the frequency and severity of the spasm. In the most distressing cases the paralysis of the nerve by alcohol injection has been recommended, but it should never be performed until the patient has been made fully aware of the disfigurement and discomfort that must ensue from facial paralysis and has clearly expressed her willingness to submit to these as a permanent substitute for spasm.

Facial hemiatrophy is a rare malady and should possibly be considered under the heading of lesions of the fifth nerve, but comes conveniently here. It is characterized by progressive wasting and atrophy of the skin, subcutaneous tissues, and muscles of one half of the face. There is no paralysis or sensory loss. Its aetiology is unknown. The process may involve the entire territory of the fifth nerve or be confined to one of the three divisions. There is no known treatment.

*Facial
hemiatrophy*

6.—THE EIGHTH NERVE

272.] The eighth or auditory nerve contains sensory (cochlear) and non-sensory afferent (vestibular) components. These components are distinct both in their central connexions and in their peripheral distribution. The non-sensory vestibular nerve subserves a complex system of co-ordinating postural reactions influencing the trunk, limb, and external ocular muscles. It is by virtue of these reflex reactions that the individual keeps 'right side up' in the world, and they have been the subject of extensive experimental and clinical studies.

*Distribution
of eighth
nerve*

About the complicated central and peripheral pathways of the eighth nerve, all that need be said here is that the nerve passes laterally from the brain-stem across the lateral recess of the posterior fossa in close company with the fifth and seventh nerves, and that it is in this situation that all three may have their functions interfered with by a tumour, the usual variety being the auditory fibroma (eighth nerve or acusticus tumour).

(1)—The Cochlear Division

The symptoms of a lesion of the nerve are deafness, tinnitus, and (rarely) auditory hyperaesthesia. The commonest cause of deafness is disease within the labyrinth and middle ear. Less common is congenital deafness, or deafness from gross lesions involving the nerve in its course from the brain to the internal auditory meatus (tumour, meningitis, aneurysm).

Nerve deafness has to be differentiated from middle-ear deafness, but of course both elements may be present in a single case. Slowly progressive lesions sometimes produce a combination of increasing deafness with tinnitus (e.g. eighth nerve tumour). Nerve deafness is differentiated from middle-ear deafness by the following tests (see also DEAFNESS, p. 555):

The Weber Test. A vibrating tuning fork is placed upon the forehead in the middle line. In nerve deafness the sound is heard better on the normal side, in middle-ear deafness on the affected side.

*The Weber
test*

The Rinne Test. Normally auditory acuity to a tuning fork is greatest when the fork is held just away from the ear. Thus if it be placed upon the mastoid process until its vibrations are no longer heard, and then held near the meatus, it again becomes audible. That is to say, air conduction is better than bone conduction. In middle-ear deafness this

*The Rinne
test*

relationship is reversed, but in nerve deafness both modes of conduction are proportionately reduced.

Tinnitus

Tinnitus may be defined as a spontaneous sensation of hearing in the absence of external sounds. It varies in pitch and character according to the exact seat of the cochlear or nerve lesion. There are many causes of tinnitus, such as middle-ear disease (otitis, acute or chronic), otosclerosis, pressure on the auditory nerve by tumour, syphilitic affections of the nerve, and chemical causes such as overdosage with quinine or sodium salicylate. Usually some degree of deafness accompanies tinnitus.

(2)—The Vestibular Division

There are two components of the labyrinth, the semicircular canals and the otolith organs (utricle and saccule). It is believed that the latter are stimulated by variations in the position of head only, the former by active movements of the head. It is probable that their functions in equilibration and movement are distinct.

In man, it is likely that the greater part of labyrinthine symptomatology is due to disordered function of the semicircular canals or their central connexions. Of these symptoms vertigo is the commonest.

Vertigo

True vertigo is a subjective sense of rotation either of the subject or of surrounding objects, but the word, and even more the word 'giddiness', is widely used in so many and so vague senses that before accepting a statement that the subject is 'giddy' the sense in which the word is being employed must be carefully investigated. It will often be found to express symptoms utterly remote from true vertigo.

Associated with the sense of rotation in true vertigo there may be a defect of balance. Indeed, this is invariably present with intense vertigo.

It may occur as a symptom of lesions involving the labyrinth or its central nervous connexions, and also with cardiovascular disease and anaemia. When due to disease of the central nervous system it is accompanied by other indications of this, but when it occurs as an isolated symptom it is commonly due to labyrinthine disease. The functional activity of the semicircular canals may be investigated by studying the nystagmus (or absence of nystagmus) evoked by irrigating the external auditory meatus with hot and cold water, but since these tests are part of the investigation of the ear rather than of the eighth nerve they will not be described here.

Menière's syndrome, the condition in which vertigo as an isolated symptom most commonly occurs, is dealt with under the title GIDDINESS.

7.—THE NINTH, TENTH, AND ELEVENTH NERVES

Distribution of nerves

273.] These nerves are so intimately related in their central and peripheral connexions and in distribution that, from the clinical point of view, they are most usefully considered together under the title of the

glossopharyngeal-vagus-accessorius complex. From the point of view of their function the fibres which make up the complex may be divided into four groups. (1) A *somato-motor* group which innervates the musculature of the pharynx, larynx, palate, and the sternomastoid and trapezius muscles. Their cells of origin lie in the nucleus ambiguus and its caudal extension. The latter runs down as far as the third cervical segment of the cord, and is here known as the spinal accessory nucleus. (2) A *viscero-motor* group which innervates the involuntary musculature of the air-passages and alimentary tract. Its cells lie in the dorsal nucleus of the vagus. (3) A *somato-sensory* group whose fibres end centrally in the substantia gelatinosa Rolandi, and peripherally innervate the ear, mouth (posterior part), pharynx, and the upper part of the respiratory tract. (4) A *viscero-sensory* group which receives fibres from the thoracic and abdominal viscera. The cells of origin of these two sensory groups lie in the ganglia of the glossopharyngeal and vagus nerves.

There is as yet no general agreement as to how the various groups of fibres are to be apportioned between the three nerves. Some maintain that the vagus is a purely sensory nerve, and that all its motor fibres really come from the accessorius nucleus. But these anatomical problems have no clinical significance, and the diseases of these nerves will be dealt with purely from the point of view of their clinical pictures. All three nerves emerge from the brain-stem in series, nine, ten, and eleven, from above downwards. They leave the skull by the jugular foramen.

The glossopharyngeal nerve distributes fibres to the mucous membrane of the posterior third of the tongue, to the pharynx and (by its tympanic branch) to the middle ear, the mastoid cells, and the Eustachian tube. It gives a motor supply to the stylopharyngeus muscle and possibly to the middle constrictor of the pharynx. It also distributes taste fibres to the posterior third of the tongue.

The vagus nerve distributes motor fibres to the voluntary muscles of the soft palate (except the tensor palati), pharynx and larynx, to the involuntary muscles of the oesophagus, stomach and intestine, and of the air-passages. It receives sensory fibres from the pharynx, oesophagus, stomach, larynx and air-passages, the external ear and dura mater. It also distributes fibres (afferent and efferent) to the heart. There are also fibres to other viscera, which are of no known clinical import.

The accessorius nerve supplies motor fibres to the sternomastoid and trapezius muscles, the levator palati, and the constrictors of the pharynx. Many of the fibres of its bulbar nucleus reach their destination through the vagus nerve.

These three nerves may be involved by lesions in the medulla, and in their peripheral course by lesions in the posterior fossa of the skull, externally at the base of the skull or in the neck.

Medullary lesions may be vascular in origin (thrombosis), degenerations (chronic bulbar palsy), syringobulbia, or tumours. The syndrome of Avellis is a medullary syndrome of this order and its signs are unilateral paralysis of the palate and of the pharyngeal and laryngeal muscles on

Glossopharyngeal nerve

Vagus nerve

Accessorius nerve

Types of lesions

Medullary lesions

Avellis's syndrome

the side of the lesion with a crossed anaesthesia of dissociated type (pain and temperature loss only) due to involvement of the spinothalamic pathway in the lateral region of the medulla. This may be seen in syringobulbia or after thrombosis of the posterior inferior cerebellar artery (see Vol. I, p. 721).

Schmidt's syndrome

There are other syndromes which may follow either medullary or peripheral lesions. When the lesion is medullary there is generally some associated crossed sensory or motor disturbance, but with peripheral lesions—generally in the region of the base of the skull—the cranial nerves alone are affected. These syndromes are: (1) Schmidt's syndrome consisting of unilateral paralysis of the soft palate, the vocal cord, the sternomastoid, and the trapezius. When the lesion is central it involves the nucleus ambiguus and its caudal extension. (2) Jackson's syndrome is the same as the above with the addition of unilateral paralysis and wasting of the tongue. When central the lesion involves the hypoglossal nucleus as well as the nucleus ambiguus.

*Jackson's syndrome**Diphtheritic paralysis*

Bilateral paralysis of the soft palate is one of the initial palsies in diphtheritic paralysis. It is then usually accompanied by paralysis of accommodation (cycloplegia) and the lesion is toxic and central.

Lesions at base of skull

Lesions at the base of the skull are of the nature of new growths, fractures (rarely), and gunshot wounds. During the War many cases of combined ninth, tenth, eleventh, and twelfth nerve lesion from wounds at the base of the skull were observed, but in civil life they are comparatively rare.

Lesions in neck

Lesions of these nerves may occur in the neck. Tapia's syndrome consists of unilateral paralysis of the vocal cord and tongue, with integrity of the soft palate. It is commonly due to trauma involving the hypoglossal nerve and the vagus at a lower level than that at which the pharyngeal branches are given off. The injury is commonly a penetrating wound below the angle of the jaw.

Tapia's syndrome

In the neck the nerves may be separately affected, and the signs of involvement of the single nerves are as follows:

Ninth nerve

The glossopharyngeal nerve is rarely if ever affected alone, and hence the determination of the consequences of its isolated paralysis is difficult. Loss of taste over the posterior third of the tongue may possibly be regarded as due to a lesion of this nerve.

Tenth nerve

A total lesion of the vagus nerve above the branching off of the recurrent laryngeal nerve produces complete paralysis of the vocal cord, which lies in the cadaveric position. If this lesion is bilateral, the cords are almost approximated and immobile and there is aphonia and inspiratory dyspnoea. In some cases (as in tabes) there is bilateral paralysis of the abductors alone. There is also paralysis of the pharynx and soft palate. The latter hangs low on the affected side, and on swallowing the posterior pharyngeal wall moves horizontally ('curtain movement') towards the normal side.

Eleventh nerve

Lesions of the spinal part of the accessory nerve produce sternomastoid and trapezius paralysis. The shoulder on the affected side cannot be

fully raised. The scapula lies unduly far from the mid-line and tends to rotate in a clockwise direction so that the mesial angle breaks the contour of the shoulder and shows as a hump when looked at from in front of the patient. There is also slight winging of the scapula when the arm is held forward below the horizontal. Winging due to serratus magnus palsy is maximal when the arm is held above the horizontal.

8.—THE TWELFTH NERVE

274.] The nucleus of the purely motor twelfth or hypoglossal nerve lies near to the mid-line in the floor of the fourth ventricle. It supplies fibres to the musculature of the tongue. Also by means of fibres partly derived from the three upper cervical nerves it supplies the geniohyoid and the infrahyoid muscles. *Distribution*

As is apparent from what has been said of the three preceding nerves, the twelfth nerve nucleus or the nerve itself may be involved by medullary lesions (vascular, degenerative, inflammatory, tumour) or by lesions of various kinds at the base of the skull, either alone or in association with other nerves. *Aetiology of lesions*

Nuclear or infranuclear lesions lead to unilateral paralysis with wasting. The affected half of the tongue is small, its mucosa wrinkled, and free fibrillary twitchings can be seen. When protruded it deviates towards the paralysed side, being thrust over by the unopposed action of the muscles in the normal half. *Symptoms of lesions*

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CRAW-CRAW

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(*Synonyms*.—Kra-kra; nodular dermatitis; ulcerating dermatitis)

History and nomenclature

275.] In 1899 Emily described some cases which he had seen in the French Congo of a disease known to the natives as crawl-crawl. The lesions were vaguely pictured as reddish-brown spots which became excoriated and later converted into superficial ulcers, the bases of which bore pale granulations and were covered with a thick pus. Since that date it has become increasingly difficult to define a single clear-cut lesion or series of lesions as characteristic of the disease. The natives of West Africa undoubtedly apply the name to a large number of affections and to practically all skin changes. According to Bennett 'bad crawl-crawl' is leprosy, and 'Krooboy's crawl-crawl' is ringworm of the glabrous skin. Confusion has been increased by the contradictory reports of different observers. Thus Blacklock stated emphatically that the crawl-crawl of the Sierra Leone creole is in every respect identical with scabies, on the grounds that the mite is indistinguishable from the ordinary *Sarcoptes scabiei* and that the nematode larvae observed in some of the lesions are not aetiologically related to the disease. This view is not generally held, although there is no doubt that natives call scabies crawl-crawl. MacLeod stated that the disease resembles inveterate scabies, both in character and distribution. Backhouse also reported the existence in New Guinea of a disease, known locally as 'kas-kas', in which the acarus is present; in fact this disease is scabies and only differs from that usually seen in Europe in that there is marked crusting and scaling. These changes occur particularly in emaciated patients with dysentery and so resemble the crusting and scaling seen in 'Norwegian scabies', in which condition the patients are in poor condition and suffering from severe tuberculosis.

Clinical features

Most authorities, however, still believe that there is a definite disease which starts as an itching papule, possibly at the site of an insect bite. These papules often become hard, horny, scaling, and sometimes crusted. Irritation is intense with the result that severe excoriations occur from scratching, and these lesions later become secondarily infected with pyogenic organisms. O'Neill was the first to detect filaria embryos in the exudate from the damaged papules. There seems some doubt whether or not *Filaria perstans* is the most common of these nematodes

for other filariae have been detected from time to time. It is true that these mixed papules and septic areas have a superficial resemblance to scabies, but they are mostly restricted to the feet and legs of the natives, although lesions on the wrists and between the fingers are found. Even in chronic cases they do not spread all over the body as they most certainly would if the acarus alone were responsible. In the rare instances in which the disease attacks the white inhabitants other exposed areas may be affected.

If this malady is due to a filaria embryo it is obvious that there cannot be an absolute distinction between it and creeping eruption. Indeed many are convinced that crawl-crawl is a form of creeping eruption due to larva migrans. In this connexion it is interesting to note that Lefrou described a linear dermatitis prevalent in Senegal where it is known as 'larbush', and stated that an exactly similar affection is seen in Sierra Leone, Ivory Coast, Liberia, Gaboon, and the Cameroons, where it attacks the feet and legs during the rainy season. Although the clinical picture is typical in that a sub-epidermal burrow advances capriciously, he has in spite of many attempts failed to find either worm or larva.

*Relation to
creeping
eruption*

Although we are accustomed to associate this disease only with West Africa, Manson saw it in other parts of that continent and also in India, Ceylon, and Southern China. There seems to be no doubt therefore that there is a curious parasitic disease which affects the feet and legs of natives in these countries. The fact that the local inhabitants apply the same name to so many different conditions ought not to conceal these particular and rarer cases under the colloquial characterization 'crawl-crawl'.

Treatment is usually along general surgical and antiseptic lines. Scabs are removed and pustules are opened, after which the lesions may be scrubbed with a lotion of mercuric chloride 1 part in water 1,000 parts. The area is then dusted over with boric acid powder and covered with an occlusive dressing of boric acid 10 per cent in white soft paraffin on lint. The dressing should not be disturbed for seven days, and when it is removed at the end of that period most lesions are soundly healed. As with all other parasitic infections, since the clothing cannot be sterilized, it is important to destroy as much as is possible, and particularly slippers, shoes, and stockings which have been in contact with the patient.

Treatment

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CRETINISM

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Reference may also be made to the following titles:

CHAGAS' DISEASE GOITRE MYXOEDEMA

1.—DEFINITION

276.] Cretinism is the condition of dwarfism and deformity attended by varying degrees of mental retardation, which results from hypothyroidism or athyroidism in the young. The term is often restricted to the states of congenital endemic and congenital sporadic thyroid deficiency, and the terms myxoedema, infantile or juvenile according to the age of onset, are used to describe cases of postnatal hypothyroidism. There seems little justification for drawing any such sharp line of distinction for the prenatal and postnatal types are essentially the same; but the changes due to thyroid deficiency during foetal life are naturally more severe than those of postnatal hypothyroidism.

When thyroid function is deficient or absent in an organism as yet undeveloped, profound developmental disturbances occur in both the physical and mental spheres, and make up the typical picture of cretinism. The endemic and sporadic forms differ in certain aetiological and pathological features, and the two conditions will therefore be considered separately in this article.

2.—AETIOLOGY

(1)—Endemic Cretinism

*Relationship
to endemic
goitre*

The problem of the aetiology of endemic cretinism is intimately bound up with that of endemic goitre. Endemic cretinism is almost invariably found in the later generations of families affected by endemic goitre. Hereditary influences play an important part in its production through the progressive and cumulative effects of the endemic noxa. The first suggestion of a relationship between endemic cretinism and endemic goitre has been attributed to Paracelsus (1616); in 1800, Fodéré observed that goitrous women were liable to give birth to cretins, but apparently did not recognize the implication of this observation. Morel (1864), quoting Billiet, expressed views very similar to those now generally held, namely, that cretinism is due to the action on the foetus of the same causes which are liable to produce postnatal goitre. In 1886, Horsley demonstrated experimentally that bitches thyroidectomized prior to, or at the commencement of, pregnancy, could give birth to pups with congenital goitre. This work was confirmed by Halsted (1896), Edmunds (1901), Carlson (1914), and extended by Marine and Lenhart (1909), who subjected bitches to sub-total thyroidectomy and withheld iodine during pregnancy. In this way litters of puppies were produced, all showing more or less thyroid hyperplasia and, in extreme cases, a condition resembling cretinism. If, on the other hand, the bitch was treated with iodine during pregnancy, a normal litter of puppies resulted. As Harington (1933) pointed out, experiments of this type make the aetiology of cretinism clear; the goitrous mother being already short of iodine for the needs of her own thyroid gland, is unable to supply adequate iodine to the foetus. As a result, the foetal thyroid undergoes hyperplasia of greater or lesser degree terminating, especially in the human species, in fibrous atrophy and hypothyroidism. The cretin is, in fact, born with a thyroid gland similar to that of a highly myxoedematous adult.

Incidence

Studies of the incidence of endemic goitre and endemic cretinism provide further evidence of a close relationship. Endemic cretinism is found only where goitre is highly endemic, and the highest incidence of endemic cretinism occurs in those areas in which the goitre incidence is highest. On the other hand, in certain areas where goitre is endemic (e.g. in certain parts of this country and of the United States, and in New Zealand) there may be little or no cretinism. This is no reason for assuming any fundamental difference between the aetiological factors in endemic cretinism and endemic goitre; the difference is one of degree only and endemic cretinism can be regarded as an extreme manifestation of the noxious influences which produce endemic goitre.

Statistical evidence is also impressive; Crotti found that 80 per cent of endemic cretins were born of goitrous parents, McCarrison that 96 per cent of mothers and 40 per cent of fathers of endemic cretins

had goitre. The influence of heredity, therefore, seems clear. It is also suggested by pedigrees which show the appearance of the condition in several members of the second and third generations of families that have emigrated from endemic areas.

It is now generally accepted that the most important factor in the *Iodine* aetiology of endemic goitre is environmental, a lack of iodine in food and water. Contributory causes must also be borne in mind, especially excess of calcium in the diet; an unbalanced diet, especially one deficient in vitamin A; some goitrogenic factor in cabbage (probably a glucoside liberating a cyanide); and a water-borne infective agency. A sufficiency of iodine, however, will prevent the development of goitre even in these circumstances.

The importance of iodine in the genesis of endemic goitre is amply borne out by the remarkable success of iodine prophylaxis in endemic areas. By this means, the incidence of goitre has been considerably reduced. For an example: in an investigation in 1917 in the school population of Akron, Ohio, amongst 2,190 schoolgirls who were prophylactically treated for three years only 5 developed goitre, as compared with 495 cases among the 2,305 who were not treated (Marine and Kimball). Similar results have been obtained in other endemic areas. It is reasonable therefore to assume that if, in the future, more extensive preventive measures justify the expectations of their sponsors, endemic goitre and endemic cretinism will to a large extent disappear.

(2)—Sporadic Cretinism

Sporadic cretinism presents a different aetiological problem. In this condition the thyroid defect may be either congenital or acquired, the same changes as those responsible for myxoedema in adults affecting the thyroid in early life. This variety is found in regions where goitre is not prevalent and bears little relationship to endemic cretinism.

It is generally considered that heredity is seldom a factor and that the *Heredity* parents of sporadic cretins are usually healthy; there are, however, no statistics on this point. Occasional examples of sporadic cretinism in which an hereditary tendency to hypothyroidism can be traced have been described; Brissaud and Spolverini reported myxoedematous parents with myxoedematous children, and I have seen three cases of sporadic cretinism in which hereditary factors were undoubtedly present. In the first, the mother suffered from hypothyroidism as a result of almost complete thyroidectomy during adolescence. In the second, simple goitre and hypothyroidism also dated to adolescence, and in the third, hypothyroidism appeared in the mother shortly after the birth of a cretin and had probably been latent during pregnancy. Such cases, however, do not appear to be common, for, in the rest of my series of sporadic cretins in which full family histories were available, there were thirty instances without any evidence of hereditary influence. Perhaps the fact that hypothyroidism in its severe forms is

accompanied by sterility, and in its less severe forms by a tendency to miscarry and abort, explains the comparative rarity of hereditary influences in sporadic cretinism.

Existing evidence as to the pathology of sporadic cretinism supports the non-hereditary view of its aetiology. It has been attributed to thyro-aplasia (or thyro-hypoplasia) or thyroid mal-development. True thyro-aplasia is probably rare; E. Thomas (1913) in his critical survey of the condition collected eleven cases in which serial microscopic sections demonstrated the absence of the gland, all showing high-grade cretinism. He called attention to the condition of dystrophic hypoplasia of the thyroid, in which the main thyroid gland is absent but its function, at least to some extent, is carried on by tiny rests of thyroid tissue at the root of the tongue. Five such examples were recorded in his series. In the majority of cases of sporadic cretinism, however, the condition can be attributed to atrophic changes in the foetal gland resulting from acute thyroiditis, probably the sequel of infective disease in the mother during pregnancy. In other instances, especially in children who develop lesser grades of cretinism after a short period of normality, thyroid atrophy may result from infective disease in the child.

Infections

The importance of infections in the aetiology of hypothyroidism at all ages is becoming more and more widely recognized, and it seems most probable that many cases of sporadic cretinism can be attributed to the exanthemata of childhood. Complete surgical removal of the thyroid in children, an obsolete operation, has been followed by cretinism without exception, as is shown in several cases in the older literature.

3.—MORBID ANATOMY AND PATHOLOGY

Endemic cretinism

Endemic cretinism seldom occurs without goitre, though the size of the thyroid enlargement varies greatly in individual cases. The consistency of the gland may be soft and diffuse or hard and nodular. Some cretins have no goitre. Scholz, for instance, found goitres in only 55 per cent of his cretinous cases. As in myxoedema, enlargement of the pituitary has been recorded. Increase in number and size of the islands of Langerhans has also been reported.

Histology of the thyroid

Histologically there are two main types of goitre. The normal lobular structure of the gland may be preserved if the changes are of the diffuse colloid type but intravesicular colloid is increased and the vesicles are enlarged. Epithelial elements also may be increased. In the course of progressive enlargement of the vesicles, their walls become distended and the epithelial cells flattened. Vesicles may burst and cysts be formed out of adjoining vesicles. In the second type, numerous nodular agglomerations may be found in the midst of normal thyroid parenchyma, the nodular goitre, or, according to some writers, thyroid adenomas. Be-

tween the two main types, all manner of transitional forms occur. Both the diffuse and nodular types result from thyroid hyperplasia, which can be regarded as a work hypertrophy of the gland from increased call on its function. Some authorities regard the two main types as distinct entities occurring in different regions, others take the view that the nodular type is only a later stage of the diffuse. Changes of one type or the other are, at any rate, found in the majority of cases of endemic cretinism.

Although in endemic cretinism the thyroid dysfunction is regarded as only one causal factor in the degenerative process, in sporadic cretinism the thyroid is essentially the focal centre of pathogenesis, the typical morbid change being atrophy of the thyroid. Colloid is practically absent, and the epithelial cells become irregular in size and shape. New formation of cells is not sufficient to offset cell death and the follicles become smaller, though still showing the infoldings of hyperplasia. The surrounding fibrous stroma increases as the follicles diminish in size. Fibrous bands develop and create the appearance of a generalized fibrosis in which nests of compressed epithelial cells remain, with or without the outlines of follicles. The interstitial fibrosis is secondary to, and consequent on, the death of the main epithelial elements. Lymphoid foci are generally scattered throughout the stroma.

*Thyroid in
sporadic
cretinism*

Unfortunately in both forms of cretinism our knowledge of the systemic pathological changes in organs other than the thyroid is still defective. We are, in fact, ignorant as to the nature of the peculiar mucoid material which infiltrates the subcutaneous and submucous tissues in cretinism as in myxoedema. Various pathological changes have been described in other members of the endocrine series. Perhaps the most important are those in the pituitary though as yet there is no uniformity of opinion as to what the characteristic changes are. Enlargement of the gland has been reported by some, atrophy by others. The majority of observers consider that the chromophobe cells of the anterior lobe are usually increased in size and number. Others have pointed out an absence of eosinophil cells in some instances. McCarrison has reported fibrosis of the parathyroids in endemic cretinism though in the sporadic form these glands are apparently normal. Persistence of the thymus has been reported by some, atrophy by others. It is obvious that further investigations are required before any conclusions can be arrived at as to the typical findings. The same is unfortunately true of our knowledge of the pathological changes in the nervous system, but all parts—central, peripheral, and autonomic—have been reported as showing retarded development and degenerative change.

*Systemic
changes in
both forms*

The most striking morbid changes in both forms of cretinism are in the bony skeleton. Dwarfism is pronounced. The extremities are affected more than the trunk resulting, in untreated cases, in a disproportioned skeleton. The skeletal deformities are the result of retardation of ossification and delayed epiphysial union, and changes in the marrow play an aetiological part in the anaemia so often found in cretinism.

Skeleton

Lawford Knaggs carefully described the osseous histological picture; this consists of a diminution in the amount of cartilage proliferation in the ossification zones, the formation of a continuous layer of bone separating the proliferating cartilage from the marrow, whilst in the marrow the active cellular tissue is replaced by fat. Periosteal as well as endochondral bone formation may be greatly retarded and the shafts of the long bones may be the site of osteoporotic and sclerotic changes. Growth may come practically to a standstill in untreated sporadic cases and the epiphyses remain largely cartilaginous to the end of life. Normally growth comes to an end when the epiphysal cartilages disappear, and their persistence in these cases explains why sporadic cretins, when submitted to thyroid treatment, grow long after the normal period.

Cranium

The cranial formation of both types is similar, the facial region and basis cranii remaining especially undeveloped. In fact, in severe degrees



FIG. 57.—Radiograph of dentition of cretin aged $10\frac{1}{2}$ —untreated—showing typical delay with retention of milk teeth

of the disease, the skull, especially at the base, retains in adult life the peculiarities characterizing the skull of a child at birth. Its infantile character may be further shown by the persistence of sutures and synchondroses. Delayed dentition is also striking (see Fig. 57).

Dentition

The osseous abnormalities in endemic cretinism are perhaps less pronounced than in the sporadic form, probably because the thyroid defect is less complete and severe in endemic cretins in early years.

4.—CLINICAL PICTURE

As the clinical picture in both forms of cretinism is very similar, the two conditions may conveniently be considered together, if attention is first directed to some of the features in which they differ. In endemic cretinism a goitre is usually present, whereas, in the sporadic form, thyroid enlargement is rare. A relationship exists between endemic cretinism and deaf-mutism; in sporadic cretinism deaf-mutism does not occur.

The main clinical features of cretinism of both types, physical and



(a) Aged 6



(d) Aged 4



(b) Aged 10½



(e) Aged 9½



(c) Aged 27



(f) Aged 27

Radiographs showing carpal development in 3 untreated (left) and
3 treated (right) cretins

close late. The fingers tend to be broad and square at the tips and the skin of the hands is dry and coarse. The reaction of the child to stimuli is peculiarly slow and characteristic. If untreated, the mental state is seriously impaired, becomes progressively slower, and in severe cases imbecility results. High-grade cretins may, in fact, be devoid of response to the ordinary physical and mental stimuli and lie about in a practically imbecile state of apathy. Another striking feature of cretinism is retardation of growth. The individual becomes dwarfed, and in an untreated case growth may come to a standstill. The long bones are affected more than those of the trunk and a disproportion of the skeleton results (see Figs. 59 and 60). Infantile bodily characteristics are retained, the measurement, for instance, from the symphysis pubis to the soles being shorter than the measurement from symphysis pubis to the vertex. The disproportion of the skeleton in untreated cases is well illustrated in the series of cases in Table I.

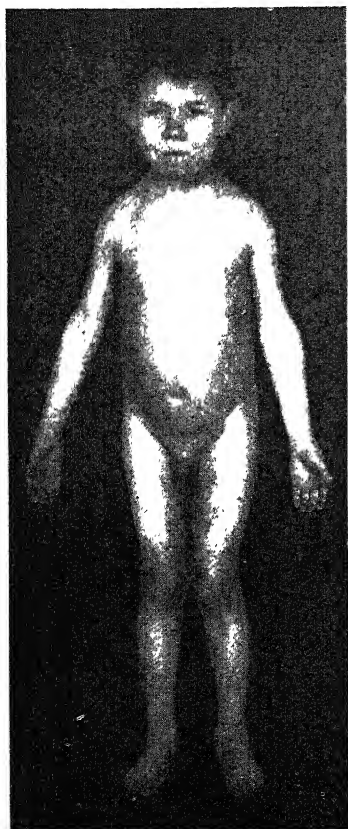
*Abnormalities
of growth*

TABLE I.—Skeletal Proportions of Cretins

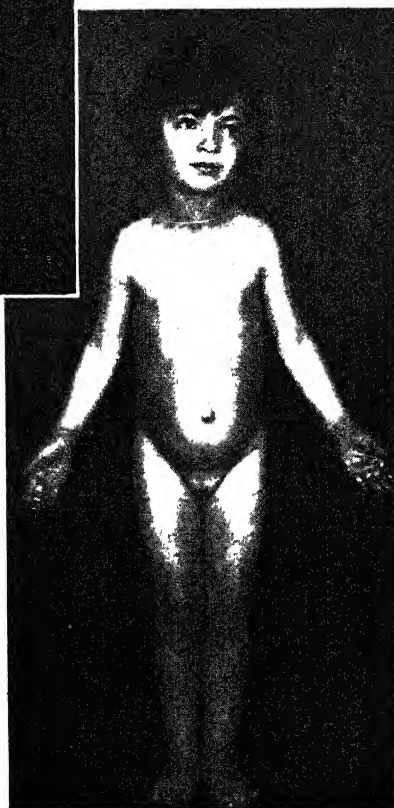
CASE	SEX	AGE IN YEARS	HEIGHT IN INCHES	PROPORTIONS		TREATMENT
				SYMPHYSIS PUBIS— VERTEX	SYMPHYSIS PUBIS— SOLES	
T. G.	M	6	36 $\frac{3}{4}$	20 $\frac{5}{8}$	16 $\frac{1}{8}$	Not treated
A. G.	F	8	44	22 $\frac{3}{4}$	21 $\frac{1}{4}$	Not treated
C. H.	F	13	49 $\frac{1}{2}$	26 $\frac{1}{4}$	23 $\frac{1}{4}$	Treated from 15/12 in- adequately
E. W.	F	13	48 $\frac{1}{4}$	25	23 $\frac{1}{4}$	Not treated
E. R.	F	19	53 $\frac{1}{4}$	27 $\frac{3}{4}$	25 $\frac{1}{2}$	Not treated
M. A.	F	27	58	30	28	Treated since 3 inadequately
E. V.	F	30	57	30	27	Treated 8–14; not since
F. H.	F	31	49 $\frac{1}{2}$	26	23 $\frac{1}{2}$	Treated for 2 years at 14
F. F.	F	38	54	28	26	Treated for a few months only at age of 4

This defect in growth is accompanied by two characteristic disturbances of bone development which can be demonstrated radiologically. Not only do the centres of ossification appear late but there is also delayed union of epiphyses and diaphyses (see Plate XI).

An untreated cretin six or seven years of age may show only one or two ossification centres in the carpus at this age instead of the full number of six or seven. Moreover, it is not unusual to find in an untreated cretin who has reached adult life that the epiphyses are still un-united. Fortunately, cretinism is now almost invariably



(a) Cretin, aged 9, untreated



(b) Cretin, aged 5, treated
 $2\frac{1}{2}$ years

FIG. 60.—Comparison of untreated and treated cretins

recognized at an early stage so that the severer grades of osseous abnormality are seldom met.

Disturbances in dentition go hand in hand with those of bone growth. *Dentition* in fact, during the first year the cretin child may remain completely toothless. In later years, the milk teeth develop very slowly and the rudiments of the permanent teeth may be found with the retained milk teeth (see Fig. 57). Treatment with thyroid accelerates skeletal and dental development.

In the untreated case the sex organs fail to develop. On the other *Sexual abnormalities* hand, with adequate thyroid treatment from an early age, normal sex development can be attained; for example, a cretin in my series, treated from early years, married and gave birth to a full term, healthy, and in every way normal child (see Fig. 59).

The thyroid defect in untreated cretinism is responsible for certain *Metabolism* metabolic abnormalities. The basal metabolism is reduced as it is in *Basal metabolic rate* myxoedema to such an extent as is found in scarcely any other pathological condition. Levels of 40 to 50 per cent below the normal limits are often recorded in fully developed cases. In my series, the average basal metabolic rate was between minus 30 and 40 per cent. Investigations of the basal metabolic rate are of great value as a means of confirming clinical diagnosis. The basal metabolism rises on the administration of thyroid and with suitable dosage can be maintained at a normal level. The reduction of the metabolic processes in cretinism is shown, as in myxoedema, by hypothermia. The temperature is almost invariably low in untreated cases.

There is some difference of opinion about the usual state of protein *Protein metabolism* metabolism in the untreated cretin: Zondek (1935) confirmed the view of the older writers that nitrogen metabolism is low, but Janney's observations suggest that it is normal.

Carbohydrate metabolism is undoubtedly disturbed in most cases of *Carbohydrate metabolism* cretinism and an increase of carbohydrate tolerance has been frequently recorded. Hypoglycaemia is often found in the fasting state and after the administration of 50 grams of glucose the blood-sugar fails to rise to the usual level. The flat type of blood-sugar curve is typical of untreated cretinism.

It has been suggested that imperfect absorption is the explanation of this abnormality, but if estimations of the respiratory quotient and respiratory exchanges are carried out during the glucose experiment, it will be apparent that this is not the case for, although after glucose the increase in oxygen consumption usually found in the normal does not occur, the respiratory quotient rises within an hour from 0.9 to 1.0 or higher. An increased capacity for the storage of glucose would therefore seem to be the most probable explanation of the low blood-sugar curve in untreated cretins. It may be added that, after a short period of thyroid treatment, a more normal sugar tolerance curve is found and this is accompanied by a rise in oxygen consumption as in the normal individual.

*Blood
picture*

Although it is well known that anaemia is a frequent accompaniment of sporadic cretinism and that the haemopoietic system is liable to suffer severely in development, there are very few actual data about the blood picture in this condition. Both haemoglobin and red cells are liable to be reduced, the former more than the latter; the colour index is consequently below unity. The white count is characterized by a diminution in the number of polymorphonuclear leucocytes, with a relative lymphocytosis. Treatment with thyroid exerts as favourable an influence on the blood picture as it does on the other pathological features of sporadic cretinism.

5.—COURSE AND PROGNOSIS

*Endemic
cretinism*

The aetiological and pathological differences between endemic and sporadic cretinism must be taken into account when considering the course and prognosis of the two conditions. The outlook is very different. The endemic cases are far more resistant to thyroid therapy than the sporadic and less uniform results can be obtained, both mental and physical. In fact, the results of therapeutic measures in the endemic form are poor. In this type, the most important consideration is the prophylactic treatment of the parents and especially of the mother. By the introduction of extensive prophylactic measures for endemic goitre in endemic areas the outlook has been definitely improved, and it may be hoped that the continued employment of these measures will ultimately eliminate cretinism in its endemic form.

*Sporadic
cretinism*

The results of treatment of sporadic cretinism, on the other hand, are on the whole most satisfactory, provided that the diagnosis is made early and appropriate treatment instituted. For the sake of convenience, the effects of treatment on the three main clinical features—disturbances of growth, and of mental and sexual development—will be considered separately.

Growth

The results of thyroid therapy on growth are most satisfactory, though the final result largely depends on the age at which treatment is begun. If thyroid therapy is instituted at an early age, the physical standards reached compare favourably with the normal (Figs. 59, 60, and 61). The effect of thyroid treatment on the growth of cretins is well illustrated in Tables II and III. In Table II the physical measurements of a series of previously untreated cretins have been compared with Holt's normal standards of height and weight for age (see Fig. 13, p. 138). In Table III a similar comparison has been made in previously treated cases, the age at which treatment was started being recorded in the last column. In a few of the second group of cases, treatment had been inadequate and the resulting growth failure will be observed. The difference in physical development attained in the two groups is obvious. In the untreated cases, there is in every instance a considerable defect in height and weight compared with the average, and bone

In this instance, when the child's attendance for treatment subsequently lapsed for a period of eighteen months, the rate of growth fell to half an inch a year. The results of treatment are equally striking in the skeletal disproportion, and in the adequately treated cases average normal bodily proportions are attained (see Fig. 61). The skeletal disproportion in untreated or inadequately treated cases is shown in Table I.

It is more difficult to assess the possibilities of improvement from thyroid treatment in the mental sphere. To obtain the best results in sporadic cretinism, it should again be emphasized that early and adequate treatment is essential. If treatment is begun late, mental development may remain much below the normal and the years lost before treatment is instituted may never be regained. A review of cases shows that the improvement in mental development has seldom been so great as in the physical sphere, though several instances could be cited in which standards above average have been attained. *Mental characters*

Defects in sex development can to a large extent be corrected by early and adequate treatment. In untreated or inadequately treated cases puberty may be indefinitely delayed and the secondary sex characteristics fail altogether to appear. In successfully treated cases, on the other hand, the changes of puberty occur at the normal age or very shortly afterwards. In females the menstrual cycle can usually be satisfactorily established. In one remarkable case to which the writer has already referred, a typical cretin, treated from an early age, married and had a normal pregnancy. This, however, is unusual in a cretin. *Sexual development*

6.—DIAGNOSIS

The clinical picture of cretinism in its fully developed form is so typical that little difficulty is likely to be experienced in diagnosis at this stage. In early and mild cases, however, the problem is more difficult, though, if the characteristic clinical features are borne in mind, suspicions of a thyroid defect should be aroused. In the first few months of life, the apathy, low temperature, and failure to thrive are important. In later life the combination of disproportioned dwarfism with mental retardation and, if the child has reached the age of puberty, sex retardation, is very suggestive. Such abnormalities may occur individually from various other causes; but, when thyrogenic in origin, they are associated, and this is important in diagnosis. As a rule, however, when such characteristic abnormalities are found, other clinical features, a sallow complexion, skin changes, and myxoedematous subcutaneous infiltration will be obvious and little difficulty in diagnosis occurs. If confirmatory evidence of thyroid deficiency is required, a basal-metabolic-rate test can be carried out. Admittedly the performance and interpretation of the basal-metabolic-rate test in a small child is difficult, but in juveniles and adolescents valuable information can

usually be obtained. In the very young more reliable evidence will be forthcoming from radiological examination of the carpus. In cretinism, as has already been mentioned, the ossification centres appear late, and in a doubtful case the typical delay will certainly be found.

*Differential
diagnosis*

The differential diagnosis must chiefly be made from two groups of conditions: the various forms of mental deficiency in childhood, and other types of physical backwardness, infantilism, and dwarfism. If it is remembered that in cretinism mental, skeletal, and sex defects occur in combination, little difficulty will, as a rule, occur.

*From mental
defects*

Of the various forms of mental deficiency which might be mistaken for cretinism, mongolism is perhaps the most likely to cause error. The clinical features of mongolism, however, are as a rule quite distinct. Moreover the mongol is active, quick in its movements and interested in its surroundings, whilst the cretin is slow, dull, and apathetic. The mongol's face with slanting eyes and epicanthic folds should be immediately distinguished from the sallow and puffy face of the cretin. The head of the mongol is characteristic, being typically short with an ill-developed occiput. There is little real resemblance between the mongol and the cretin, and this error of diagnosis should not be made. Other forms of mental deficiency can usually be differentiated by the history of fits, physical signs of diplegia, spasticity, disturbance of reflexes, and other signs of disease or degeneracy—abnormalities which are not found in the cretin.

*From
dwarfism*

The differential diagnosis from other types of physical backwardness, especially dwarfism, is perhaps more difficult. In the untreated or inadequately treated cretin, the dwarfism is disproportioned. Of disproportioned dwarfs the most common are those in whom the condition is due either to one of the forms of rickets—simple, coeliac, or renal—or to hypopituitarism. Mental changes are, as a rule, not present in any of these conditions and the children are usually alert and bright and their behaviour is in striking contrast to that of the cretin. Occasionally hypopituitarism is complicated by a secondary thyroid defect, but such cases are not common. In uncomplicated hypopituitarism the disturbances of ossification are similar to those in cretinism, but the general clinical features of the two conditions are so entirely dissimilar that little confusion is likely to occur. Rickets in its various forms produces characteristic bony deformities and, if the condition is active, typical changes will be revealed by radiography of the diaphyses.

*From
chondro-
dystrophy*

A comparatively rare form of chondrodystrophy may present a superficial resemblance to, and so possibly be confused with, cretinism. In these unusual cases skeletal deformities are prominent and dwarfism is disproportioned, the long bones being affected more than the trunk and the lower limbs short, thick, and bowed. The hair is generally sparse as in the cretin, but fine and silky. Mentally these individuals are alert. This fact, taken in conjunction with characteristic bony changes which can be demonstrated radiologically, should enable a distinction to be made between chondrodystrophy and cretinism.

7.—TREATMENT

The essential consideration in the treatment of cretinism of both forms is the administration of thyroid in adequate dosage. Though the results of thyroid therapy in endemic cretinism are unsatisfactory, this treatment restores sporadic cretins to comparatively normal physical and mental health which is maintained as long as the administration of thyroid is continued. It is important to remove any possible cause of thyroid depression but when the disease has once developed, causal factors are usually no longer playing an active part in the maintenance of the condition.

*Thyroid
therapy*

The aim in all cases of cretinism is clear. The basal metabolism must be brought to the normal level and there maintained by an appropriate daily dose of thyroid. If estimations of the basal metabolism are not possible, accurate records of pulse rate and weight should provide a reasonably satisfactory substitute. The chief difficulties in the past in obtaining the best results in the treatment of cretinism have been, first, the absence of any reliable method of judging the dose required, and secondly, the variations in potency of the different thyroid preparations available. Both these difficulties have now been overcome, the former by the introduction of the basal-metabolic-rate test and the latter by the general use of desiccated gland, following its official recognition by the British Pharmacopoeia. When 'thyroid', 'thyroid extract', or 'thyroid gland' is ordered the pharmacist will dispense a desiccated preparation of the gland standardized to contain 0.1 per cent of iodine in combination as thyroxine. The activity of unstandardized fresh or dry gland may vary within very wide limits—e.g. one unstandardized preparation may be 6 or more times as active as another; and similar variations may exist among standardized 'fresh gland' products. It was thought that the introduction of synthetic thyroxine by Harington a few years ago would result in a further improvement in the treatment of hypothyroid conditions, but the clinical results have been disappointing and most clinicians would probably agree that thyroxine is less effective in controlling thyroid deficiency than desiccated thyroid, though a similar rise in basal metabolic rate can be obtained.

Most cretins are sensitive to thyroid and it is therefore advisable to begin with a small daily dose and increase it gradually at intervals of a week or so until the appropriate maintenance dose has been found. This fractional method of introducing thyroid treatment gives good results and avoids the risk of overdosage in the early stages. The usual method is to start with $\frac{1}{4}$ grain of desiccated thyroid once a day, increasing to $\frac{1}{4}$ grain twice a day at the end of a week, $\frac{1}{2}$ grain twice a day at the end of another week, and $\frac{3}{4}$ grain three times a day subsequently. In the average case, the maintenance dose required is one grain to $1\frac{1}{2}$ grain a day, but it varies to some extent with the age

Dosage

of the individual. No hard and fast rules can be laid down and dosage must be judged by results. The parents of a cretin should be warned that the child will have to continue thyroid treatment throughout its life and that successful results depend to a large extent on the systematic supply of thyroid in the right dosage. Since the effects of the remedy are so obviously beneficial, there is seldom any difficulty in obtaining the complete co-operation of the parents. This slow method of introducing thyroid therapy is suitable for ambulatory cases. If quicker results are desired the patient should be put to bed, when the increases can be made at shorter intervals. The usual method with the patient in bed is to increase the dose by $\frac{1}{4}$ grain every other day until the full maintenance dose has been found.

Overdosage

A warning is necessary as to symptoms of overdosage and thyrotoxaemia, and the writer would draw a distinction between the two. The ill effects of the former usually quickly pass off on the withdrawal of thyroid. The effects of thyro-toxaemia are more lasting. When this latter complication has occurred in the writer's experience, it has usually been due to the presence of a septic focus or to the patient taking thyroid extract during an infective illness—for example, one of the exanthemata or tonsillitis. A persistent tachycardia develops with other signs of cardiovascular disturbance and the child loses weight. In view of the possibility, therefore, that this complication may arise, it is advisable, when instituting thyroid treatment in cretinism, in the first place to make sure that all septic foci have been dealt with and, secondly, to warn the parents to discontinue treatment if any intercurrent infective illness occurs. The danger of this complication developing if thyroid treatment is not withheld during an infective illness should be emphasized: in the writer's early experience, two cretins became thyrotoxic as a result of continuing to take thyroid during attacks of acute tonsillitis and one subsequently died of cardiac failure. Thyroid administration should be recommenced when the infective condition has passed off. Simple overdosage seldom occurs if the fractional method of treatment is employed at the start, though when thyroid is being taken for long periods it is always a wise precaution to withhold it periodically for two or three days at a time to avoid cumulative effects.

In conclusion, it cannot be over-emphasized that, to obtain good results in the treatment of cretinism, the diagnosis should be made at the earliest possible stage and treatment carried out regularly and, with the above exceptions, continuously.

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CROHN'S DISEASE

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1.—DEFINITION AND AETIOLOGY

(*Synonym.*—Regional ileitis)

277.] In 1932, Crohn in conjunction with Ginzburg and Oppenheimer published the first description of the clinical manifestations associated with certain morbid changes occurring in the terminal part of the ileum. They gave the name of regional ileitis to this condition, but the title of Crohn's disease is now usually employed. Many isolated descriptions of the condition can be found scattered in the literature, but it was generally regarded as tuberculous and no attempt was made to describe its clinical history. Now, however, it is not infrequently diagnosed in America and more recently in England as a result of Crohn's work, and it is clear that regional ileitis is by no means a clinical rarity, though it is quite unrecognized on the Continent except in Holland. Young adults are chiefly affected but cases have been recorded between the ages of 4 and 50. It is seen twice as commonly in males as in females.

Incidence

2.—MORBID ANATOMY

In the majority of cases the disease originates in the terminal portion of the ileum. The first changes apparently take place just proximally to the ileo-caecal sphincter and from there they progress mainly away from the sphincter, but in the more advanced cases the caecum is usually involved and small areas in other parts of the small intestine and colon may be affected. The pathological process is of an inflammatory nature, the most marked changes occurring in the mucosa and submucosa. Ulceration of the former occurs and finally all coats of the affected

*Changes in
ileum and
caecum*

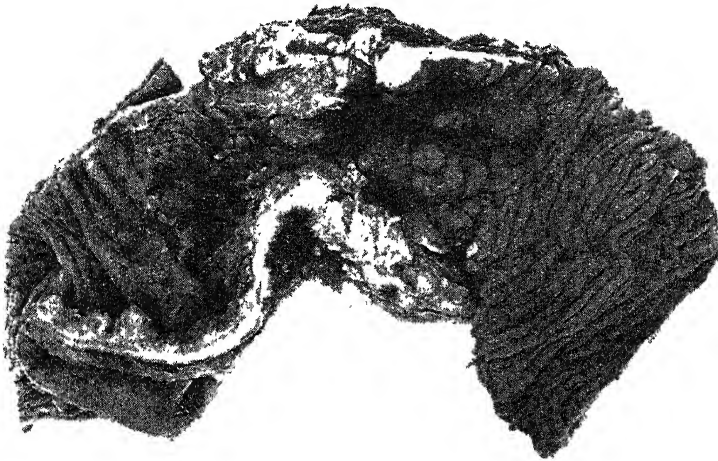


FIG. 62.—Photograph showing the terminal ileum, caecum, and first part of the ascending colon removed at operation from a case of Crohn's disease under the care of Dr. Hurst. (Reproduced by kind permission of Professor G. Payling Wright)

segment become involved in the granulomatous process. Fibrotic changes supervene and great narrowing of the lumen results (see Fig. 62), particularly in those areas in which the disease is of longest duration. The regional lymphatic glands are enlarged and there is usually some thickening of the mesentery. The affected portion of the intestine, usually the last few inches, is red, thickened, rigid, and oedematous and presents a 'hose pipe' appearance. The inner aspect shows marked narrowing of the lumen with ulceration of the mucosa. In cases of long duration dense adhesions form between adjacent parts of the bowel, and a striking feature of the disease is the tendency to fistula formation between different segments of the small intestine, the caecum, and occasionally the skin.

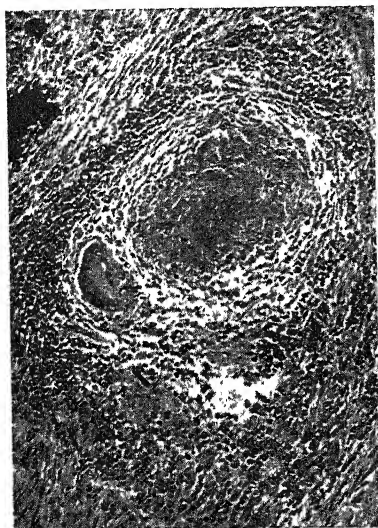
On histological examination (Fig. 63) signs of acute, subacute, and chronic inflammation are found, but there are no characteristic specific

Histology

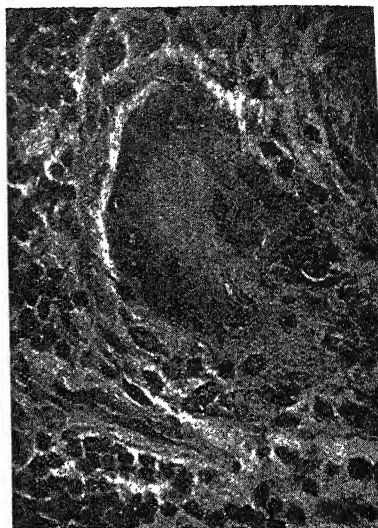
changes. Giant cells are commonly present, and there may be a very close resemblance to tuberculous disease. Indeed, there is no doubt that many cases of Crohn's disease have, in the past, been so diagnosed, but tubercle bacilli have never been found in the diseased segment of bowel or in the stools, and the ileitis is not associated with tuberculous disease in other parts of the body.

Pathogeny

Nothing is known about the cause of the inflammatory reaction. It is



(Magnification: $\times 140$)



(Magnification: $\times 600$)

FIG. 63.—Photomicrographs from the specimen seen in Fig. 62 illustrating tubercle-like structures and showing giant-cell formation. (Reproduced by kind permission of Professor G. Payling Wright)

probably infective in origin, but it has been suggested that it may result from various non-specific irritants, both bacterial and physical.

3.—CLINICAL PICTURE

Onset

Predominant symptoms

Although a number of intra-abdominal conditions may at times be simulated by Crohn's disease, yet the majority of cases present a fairly typical symptomatology. There is, as a rule, a history of some months' illness, during the course of which, in a large proportion of cases, an unavailing appendicectomy has been performed. The predominant symptoms consist of attacks of colicky pain in the umbilical region and right iliac fossa, intermittent fever, usually of a mild order, together with diarrhoea as a fairly constant feature, and occasional attacks of vomiting. In some cases constipation alternates with diarrhoea or is present alone. As the disease progresses anorexia appears with loss in weight and the development of anaemia. Occasionally the general symptoms may precede those of intestinal origin.

The most important of the physical signs is the presence in the right iliac fossa of a movable sausage-shaped tumour which is produced by the affected segment of bowel, but it is not always possible to discover it owing to the distension of the small intestines. There is a variable degree of muscular guarding and tenderness in this region. In long-standing cases one or more fistulae may open on the surface and form the presenting symptom. Evidence of chronic intestinal obstruction is usually forthcoming, and this is best obtained by hourly X-ray examinations for six hours following the ingestion of an opaque meal. In addition to the delay in passage of the barium, evidence of small-intestine obstruction is afforded by the recognition of dilated loops of bowel containing gas and fluid (Plate XII, A). It is often possible to detect filling defects in the terminal ileum and sometimes in the caecum. Kantor's 'string sign'—a narrow, irregular, opaque streak connecting the dilated ileum with the caecum is characteristic when seen (Plate XII, B) but is not invariably present. The constriction of the terminal ileum is, in certain cases, better revealed by means of a barium enema, the incompetent ileo-caecal valve allowing the upward passage of some of the opaque fluid. Occult blood is always present in the faeces, and in those cases in which diarrhoea is a prominent symptom the watery stools may contain macroscopic blood and shreds of mucus. A slight polymorphonuclear leucocytosis may be present, but more usually the white count is normal.

*Physical signs**Radiology**Faeces**Blood changes*

4.—PROGNOSIS

The good prognosis that is attendant upon appropriate treatment in these cases is sufficient indication of the importance of diagnosing Crohn's disease. In the absence of suitable treatment the condition runs a slowly progressive course, and the longer its duration the greater is the likelihood of obstructive symptoms developing and the more intense is their severity.

Following the radical removal of the diseased bowel, however, complete and rapid recovery is the rule. There appears to be little tendency to recurrence, but there is a risk of this in cases in which a sufficiently wide resection has not been performed.

5.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The differential diagnosis is largely dependent on the predominant symptom or sign in any particular case. The frequent combination of recurrent bouts of fever with pain, tenderness, and a palpable mass in the right iliac fossa commonly leads to a diagnosis of subacute appendicitis with the consequent removal of the appendix. Hence the stress that is laid on the presence of a comparatively recent appendicectomy scar as a frequent 'physical sign' in Crohn's disease. The possibility of

Diagnosis from appendicitis

*From
ulcerative
colitis*

*From other
conditions*

this condition should, moreover, always be borne in mind in obscure cases of chronic obstruction of the small intestine. In those cases in which diarrhoea is the prominent symptom the presence of blood and mucus in the motions may lead to an erroneous diagnosis of ulcerative colitis, but this can be excluded by the watery character of the stools and the absence of any sigmoidoscopic evidence of disease. Finally, the various causes of a palpable mass in the right iliac fossa may give rise to difficulty. In this connexion a misdiagnosis of ileo-caecal tuberculosis, carcinoma of the ileum, and less frequently of lymphosarcoma or of Hodgkin's disease may be made. If fistulae are present differentiation must be made from actinomycosis. It is probable that, at present, cases of Crohn's disease are more often diagnosed as one or other of the above conditions rather than the converse.

6.—TREATMENT

*Surgical
methods*

Any medical measures are but palliative and surgery should always be employed. When possible, and in the majority of cases this is so, the affected segment together with a margin of healthy bowel at either end should be resected. A short-circuiting operation alone is unsatisfactory, as further extension of the disease in both directions is apt to occur. However, this more simple operation may be the only possible one in advanced cases with widespread adhesions and extensive involvement of the mesentery and lymphatic glands, and also as a preliminary measure when fistulae have formed.

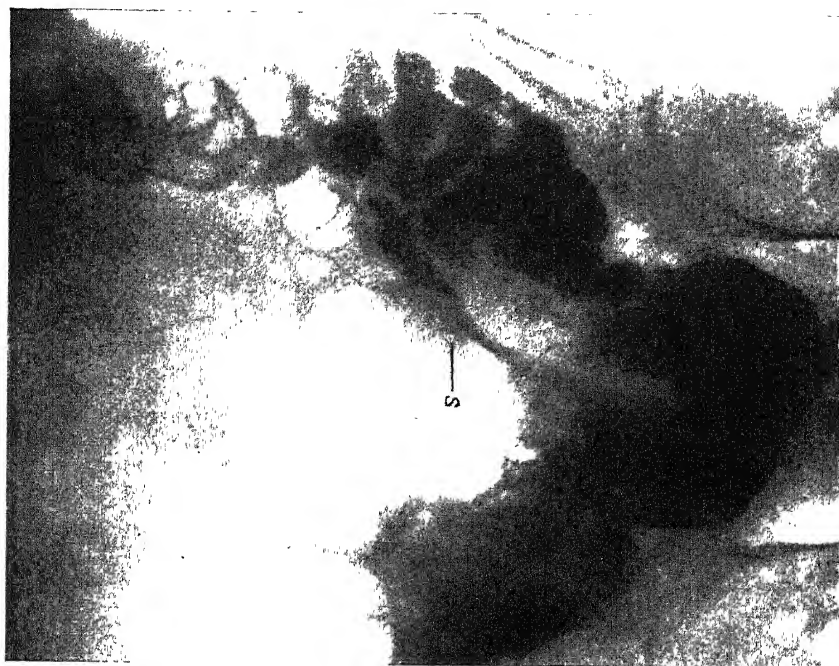
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A

A.—Radiogram without opaque meal showing gas and fluid levels in dilated coils of small intestine in regional ileitis. B.—Radiogram taken 4½ hours after opaque meal, showing string sign (S) in affected segment of ileum; from same case as A. Complete relief followed short-circuiting



B

PLATE XII

(Dr. P. J. Briggs)

CROUP

See ASPHYXIA IN CHILDREN, Vol. II, p. 173; DIPHTHERIA;
and LARYNX DISEASES

CRYPTORCHISM

See TESTIS, UNDESCENDED

CUSHING'S SYNDROME

See ADIPOSITY, Vol. I, p. 216; *and* ADRENAL GLAND
DISEASES, Vol. I, p. 246

CUTIS VERTICIS GYRATA

See ACROMEGALY, Vol. I, p. 167; *and* SKIN TUMOURS

CYANOSIS

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Reference may also be made to the following titles:

ASPHYXIA	CYANOSIS, ENTEROGENOUS
ASPHYXIA IN CHILDREN	HAEMOCHROMATOSIS
BLOOD EXAMINATION	HEART
BRONZING OF THE SKIN	

1.-PATHOLOGY

278.] The primary cause of cyanosis is the bluish colour of the capillary blood, but its intensity is determined by secondary factors, such as the degree of filling of the capillaries, their distance from the surface, and the pigmentation of the overlying skin. With a given degree of lack of oxygen in the blood, full capillaries cause a deeper colour, whereas the cyanosis is more leaden coloured when these vessels contain less blood. The change in colour is usually due to reduced haemoglobin, but occasionally cyanosis is due to other pigments such as methaemoglobin and sulphaemoglobin. The two main divisions of cyanosis are: (1) arterial anoxaemia, i.e. a lack of oxygen in the arterial blood; (2) delayed rate of flow in capillaries.

The arterial blood normally contains almost as much oxygen as it can carry. This is in the neighbourhood of eighteen volumes of oxygen per

*Arterial
anoxaemia*

hundred volumes of blood. When oxygenation in the lungs is incomplete, the blood in the left heart, arteries, and capillaries is already in a somewhat venous state. This is called arterial anoxaemia. After the tissues have absorbed their normal amount of oxygen the blood returning in the veins is still more venous, and therefore appears more blue than normal.

The essential cause of arterial anoxaemia is a short-circuit of venous blood. This may take place either in the lungs, in the heart, or through the ductus arteriosus as in congenital heart disease. The short-circuit of venous blood from the right heart to the left reduces the average level of oxygen in arterial blood. Such a short-circuit more commonly occurs in disease of the lungs such as lobar pneumonia at the stage of red hepatization.

*Causes of
arterial
anoxaemia*

Cyanosis from stasis is explained in the following way: when the blood flow is slowed for any reason, e.g. by cold, or by obstruction, or in congestive heart failure, the tissues have more time to take oxygen out of the capillaries, so that the venous blood is more reduced than when the blood flow is fast.

Stasis

Certain drugs are well known to cause cyanosis by conversion of the normal blood pigment into methaemoglobin. The condition is met with in sufferers from chronic nerve pains such as sciatica, who have been taking analgesics containing aniline compounds for long periods. It is by no means clear why the condition is more readily produced in some cases than in others. One of the more commonly used drugs which is found to produce methaemoglobinaemia is phenylacetamide (acetanilide), which is a constituent of some widely advertised 'headache powders'. Nitrites and potassium chlorate may produce the condition. It is readily diagnosed by spectroscopic examination either of the shed blood or through the web of the fingers. When well-marked, the abnormal colour of the blood is obvious to the naked eye. The so-called enterogenous cyanosis is said to occur as the result of an intestinal infection with consequent sulphaemoglobinaemia, but its mechanism is not yet understood (see p. 520).

*Drugs
causing
methaemo-
globinaemia*

2.—DIAGNOSIS

(1)—Of Cyanosis

Cyanosis is quickly detected by an experienced person, but it is astonishing how it can be overlooked by the unobservant. This is perhaps because cyanosis of the extremities of some degree is common in extreme cold in healthy persons. The condition is particularly apt to be missed when the surface capillaries are poorly filled. It is also worth pointing out that the site of cyanosis is important. For acrocyanosis see ERYTHEMA.

When cyanosis is due to a lack of oxygen in the arterial blood, the bluish colour is particularly noticeable in the lips, where the vascularity

*Sites of
cyanosis*

*Effect of
anaemia*

is rich. In mitral stenosis, when cyanosis is due to the slow blood flow, the cyanosis is apt to be most noted in the typical malar flush, which is rarely absent except in the case of anaemia. Incidentally, it may be noted here that true cyanosis may diminish after haemorrhage, and is not seen in advanced anaemia. Several factors are responsible for this, including the low concentration of reduced haemoglobin, which must be at a certain level to be visible, the poor state of filling of the superficial capillaries, and, if stasis plays a part in the cyanosis, the increased rate of the blood flow caused by the anaemia.

The tips of the ears sometimes show cyanosis, but not as well as the lips. A patient in bed who is unable to see his own lips and cheeks in a glass, may comment on the colour of the palms of the hands, especially in methaemoglobinaemia.

*Effect of
exertion*

In addition to the site, the effect of slight exertion may be noticed in the diagnosis of cyanosis. When the condition is due to stasis alone, as in mitral stenosis, movement, such as sitting up and down in bed, may remove it entirely. This is due to the acceleration of the blood flow. But when cyanosis is due to abnormal pigment, as in methaemoglobinaemia, the slightest exertion may produce a lividity of startling intensity, presumably because the facial congestion from fuller capillaries brings an increased amount of abnormal pigment to the surface. Exertion also may intensify the cyanosis of arterial anoxaemia.

*Measurement
of degree of
cyanosis*

If it is desired to measure the degree of cyanosis for purposes of accurate study, reference should be made to the valuable article by Lewis (1929), which shows the range of standard colours, and gives instructions on how to mix them.

*Variations
in colour*

As stated above the colour of the skin in true cyanosis may vary from a deep plum-colour to a leaden grey. The former colour is never closely simulated at rest by any of the rarer forms of cyanosis such as methaemoglobinaemia, or by the skin pigmentations seen in argyria or haemochromatosis. But all the latter conditions may give a tolerable imitation of a leaden cyanosis. Moreover, the difficulty of diagnosis may be increased by the fact that, as has been pointed out, movement in bed intensifies a pigmentary cyanosis such as methaemoglobinaemia and thus suggests the presence of pulmonary or circulatory disorders. The distribution of the colour in methaemoglobinaemia is more general, especially on the whole face, and it is never most striking over the malar bones, as in mitral stenosis.

*Pigmentation
in haemo-
chromatosis*

The intensity of the colour in argyria and haemochromatosis is not changed by exercise since the pigment is in the skin and not in the blood. At rest, however, the pigmentation of haemochromatosis may closely simulate methaemoglobinaemia if it is slaty instead of brown in colour. The presence of sugar in the urine, and signs of an enlarged cirrhotic liver should suggest haemochromatosis, though the diagnosis may rest on the histological appearance of the skin.

*Cyanosis in
negroes*

The existence and degree of cyanosis in the negro must be judged from the mucous membranes and conjunctivae. The pigmentation of some

half-breeds may be erroneously regarded as pathological (e.g. haemochromatosis) unless careful inquiry is made into the past history and the appearance of other members of the family.

(2)—Of some Diseases causing Cyanosis

Congenital heart disease is the commonest cause of chronic cyanosis in children. The association with clubbing of the fingers is typical. Haemoglobin and red cells are increased, as they are in all causes of arterial anoxaemia. *Congenital heart disease*

Mitral stenosis is the most frequent cause of chronic cyanosis in apparently healthy women. The typical malar cyanotic flush may suggest the diagnosis, which is confirmed by auscultation of the heart. *Mitral stenosis*

Congestive heart failure always produces cyanosis, by stasis, especially when it is associated with complete irregularity of the pulse as seen in auricular fibrillation. *Congestive heart failure*

The cyanosis of heart failure may have a second origin in addition to reduced rate of circulation; in the presence of pulmonary oedema of heart failure, the mechanism of a venous short-circuit described above increases the degree of cyanosis.

Lobar pneumonia is always associated with arterial anoxaemia, but it is important to realize that the cyanosis is not proportional to the lack of oxygen in the arterial blood. Cyanosis may be slight when oxygen lack is severe. *Anoxaemia from pneumonia*

In many other inflammatory conditions of the lungs, as also in some cases of cardiac failure, pulmonary oedema is present. This prevents access of oxygen to the venous blood, and cyanosis results. A clear instance of this was seen in the War in poisoning by chlorine gas. *Pulmonary oedema*

In elderly men, otherwise healthy, emphysema may cause well-marked cyanosis from arterial anoxaemia. This condition is diagnosed much more often than it really occurs (see EMPHYSEMA). To produce cyanosis apart from severe effort it must be extensive. Startling lividity in an apparently well man of fifty should suggest this possibility. The haemoglobin is raised in this condition. *Cyanosis from emphysema*

It is surprising how far advanced pulmonary tuberculosis may be before cyanosis becomes prominent; but a very slight attack of bronchitis in a subject who already has advanced fibrosis is sufficient to cause striking cyanosis and severe respiratory embarrassment. Miliary tuberculosis may at first present no other clinical sign than slight cyanosis and tachypnoea. *Pulmonary tuberculosis*

In addition to the factors already mentioned, any of the causes of asphyxia may also produce cyanosis, especially obstruction of the larynx or trachea by malignant disease (see ASPHYXIA, Vol. II, p. 168). Thoracic tumour, including aneurysm, tends to obstruct veins, such as the superior vena cava, which greatly increases the cyanosis and may also cause oedema. *Obstruction*

Cyanosis is seen in polycythaemia splenomegalica, associated with overfilling of the veins and a tendency to thrombosis from the slow *Polycythaemia splenomegalica*

*Acute
abdominal
conditions
Other
conditions*

rate of flow. Cyanosis, associated with lumbar pain, may occur in acute abdominal conditions, such as acute pancreatitis.

Numerous other conditions may produce cyanosis, but they all act in the ways already illustrated. Thus bronchial obstruction caused by foreign bodies is an uncommon cause. Goitre alone rarely causes cyanosis. Swelling of the root of the tongue, as in acute septic tonsillitis or Ludwig's angina, is not likely to offer any difficulty in diagnosis. Asthma as a cause of blueness is usually obvious.

3.—TREATMENT

(1)—Of Cyanosis

The first principle to be realized is that, especially in acute lung diseases such as pneumonia, cyanosis means anoxaemia of the tissues. This condition is extremely serious and should not be allowed to continue. It must be combated by the early administration of oxygen.

*Lobar
pneumonia*

The severity of the anoxaemia cannot be judged by the *degree* of cyanosis. The leaden cyanosis may be of more serious import than the deeper plum-coloured variety. There can be no doubt that oxygen administration reduces the pulse rate, removes delirium, and promotes sleep. It should therefore be used as a routine in pneumonia, both lobar and bronchial, whatever the age of the patient. It is also indicated in other cyanotic conditions in which there exists arterial anoxaemia from any acute pulmonary cause.

Heart failure

Oxygen should be administered in the treatment of the pulmonary oedema of congestive heart failure. If ventilation is adequate, as it usually is, the addition of carbon dioxide to the oxygen is unnecessary.

Stasis

In the absence of any superadded arterial anoxaemia, the use of oxygen in the cyanosis of stasis is practically valueless.

*Respiratory
obstruction*

When cyanosis is caused by obstruction of the trachea, the immediate treatment is to free the airway, for example, by removal of foreign bodies if present, or by intubation as in diphtheria, or by tracheotomy as in malignant disease of the larynx. If for any reason such measures cannot be adopted at once, oxygen should be given in the interval.

*Allergic
oedema*

In acute allergic oedema of the glottis, 5 minims of adrenaline hydrochloride (1 in 1,000) should be injected and, if necessary, repeated at intervals for four doses.

*Methaemo-
globinaemia*

Oxygen therapy is of no value in methaemoglobinaemia. In the treatment of this condition all drugs should be stopped, after which the blood will return to normal very slowly. In full-blooded patients who can tolerate a small venesection this treatment will hasten recovery.

*Mediastinal
pressure*

In cyanosis due to mediastinal pressure, as in cases of neoplasm or aneurysm, the prognosis is grave, most patients surviving for a few months only. Especially severe are cases of rapid onset, associated with oedema of the face, neck, or arms. But some tumours of lymphatic

tissue are, at least for a time, sensitive to deep X-ray therapy, which is always worth a trial.

(2)—Of some Emergencies associated with Cyanosis

Except for laryngeal obstruction, which sometimes occurs rapidly, the causes of a sudden onset of cyanosis are not numerous. Coronary thrombosis is often associated with sudden cyanosis with or without the characteristic continuous pain in the chest (see Vol. I, p. 567). An injection of morphine sulphate $\frac{1}{4}$ grain is often necessary, and since pulmonary oedema is apt to occur from left ventricular failure, oxygen should be given. *Coronary thrombosis*

Cyanosis may be part of general asphyxia during anaesthesia; when this occurs, the airway must be cleared, oxygen supplied, and if necessary artificial respiration performed. *Anaesthesia*

The prognosis in acute pulmonary oedema again depends on the cause. It is commonly fatal in sudden weakness of the left ventricle after coronary thrombosis. In cases associated with mitral stenosis, immediate venesection may rapidly relieve the extreme cyanosis, and a few hours later the patient may feel quite well. Morphine sulphate ($\frac{1}{8}$ to $\frac{1}{4}$ grain) should also be given, but atropine is now considered valueless. *Acute pulmonary oedema*

Pulmonary embolism is sometimes associated with cyanosis. Cases are either rapidly fatal, or else recover without special treatment. Successful embolectomy has been reported. *Pulmonary embolism*

Spontaneous pneumothorax may very rapidly cause cyanosis. The history of a sudden severe pain followed by increasing dyspnoea is usual. The emergency treatment consists in drawing off air from the pleural cavity, where it has accumulated at high pressure. This is best done with a fine hollow needle two inches long, to which is attached a piece of light rubber tubing; the end of the tubing opens under water in a vessel placed on a level below that of the patient. *Spontaneous pneumothorax*

For the treatment of cyanosis of the new born, see Vol. II, p. 175. *Cyanosis of the new born*

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CYANOSIS, ENTEROGENOUS

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Reference may also be made to the following titles:

CYANOSIS

ERYTHRAEMIA

(Synonyms.—Sulphaemoglobinaemia; methaemoglobinaemia)

Definition 279.] Enterogenous cyanosis is a disease characterized by chronic cyanosis, unassociated with dyspnoea or polycythaemia, due to the presence of sulphaemoglobin or methaemoglobin in the blood.

Aetiology The disease is believed to be due to the presence in the blood of a foreign substance which favours a combination of haemoglobin with sulphur, or the reduction of haemoglobin to methaemoglobin. Sulphaemoglobin was first differentiated from methaemoglobin by H. van den Bergh (1905). Acute poisoning with sulphuretted hydrogen does not cause sulphaemoglobinaemia, which strongly suggests that some intermediary substance is necessary for this combination to take place. The list of substances known to 'activate' red cells and allow sulphaemoglobin or methaemoglobin to be formed includes phenacetin (Snapper, 1925), acetanilide, methylsulphonal (trional), sulphonal, plasmoquine, ammonium nitrate, potassium chlorate, prontosil (Colebrook and Kenny, 1936), pyridium and *m*-dinitrobenzene (furniture polish). The condition occurs only in sensitive persons and is said to arise more easily if some of the above substances are taken in association with magnesium sulphate. Idiopathic cases also occur in which no history of drugs or chemicals can be obtained and, rarely, the condition may be present from birth. Mackenzie-Wallis (1913) offered an explanation of the idiopathic disease by demonstrating a reducing substance in the urine, blood, and saliva of affected persons and by isolating a nitroso-bacillus from the saliva. This organism had the power of reducing nitrogen compounds. The same organism was found by Garrod (1925) in the faeces of two patients. It seems certain that reducing agents accelerate the conversion of oxyhaemoglobin into sulphaemoglobin.

Whatever may be the cause of the corpuscular sensitivity, it is established that the source of the sulphuretted hydrogen is the intestine. The disease occurs therefore in constipated persons.

Incidence The condition is very rare; it affects females more than males and is

usually found in early adult life. The features of the disease are discussed by Harrop and Waterfield (1930) and by Healy (1933).

There are recurrent attacks of cyanosis with periods of relative freedom. With sulphaemoglobinaemia the cyanotic tinge is a leaden-blue, whereas with methaemoglobinaemia the colour is chocolate-brown. When the condition is severe, the skin and mucous membranes may appear almost black. The most striking feature is the absence of dyspnoea and of any cardiac or pulmonary lesion. Weakness is usual, constipation invariable, and most patients complain of severe headache. Nervous and mental symptoms are common.

Clinical picture

The idiopathic disease is a chronic condition which is relieved, but not cured, by proper treatment. In cases in which the condition is due to drugs or chemicals, a cure can be anticipated when the cause is removed. Death from the condition alone is unusual, but in drug addicts circulatory depression may prove fatal.

Course and prognosis

Central causes of cyanosis, such as diseases of the heart and lungs, must be excluded. A simple blood count eliminates erythraemia (polycythaemia vera). In a cyanosed patient without any signs of respiratory distress the blood should be examined for abnormal pigments and for cellular changes (see BLOOD EXAMINATION, Vol. II, p. 457). The blood count may be normal but there may be a hypochromic anaemia or, with severe drug poisoning, a marked anaemia of haemolytic type. The abnormal pigments are intracorpuseular; the blood serum is therefore normal in colour. The absorption spectrum of sulphaemoglobin occupies the wave-lengths 607–20 Å; that of methaemoglobin from 618–30 Å. To differentiate the two spectra, ammonium sulphide and 1 per cent potassium cyanide solution should be added to a weak watery solution of the blood; the absorption band of sulphaemoglobin is unaltered whereas the band of methaemoglobin disappears. If both compounds are present the absorption bands overlap, but the above test causes the disappearance of the overlapping methaemoglobin band (for spectra see Vol. II, Plate VI, facing p. 499).

Diagnosis

Any offending drug or chemical must be inquired into and withdrawn. In clear-cut cases the cyanosis of methaemoglobinaemia disappears within forty-eight hours of withdrawing the drug, but with sulphaemoglobinaemia the cyanosis may persist for weeks. Purgation (not with magnesium sulphate), and irrigation of the colon with solution of potassium permanganate, must be carried out in the early stages. The diet should contain plenty of carbohydrate and the minimum of sulphur. Ammonium chloride, 15 grains four times a day, is said to assist recovery.

Treatment

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CYCLICAL VOMITING

See ACIDOSIS, Vol. I, pp. 146 and 150; ALLERGY, Vol. I,
p. 306; *and* VOMITING

CYCLOTHYMIA

See PSYCHOSES AFFECTIVE (MANIC AND DEPRESSIVE STATES)

CYSTICERCOSIS

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Reference may also be made to the following titles:

EPILEPSY

TAPEWORMS

1.-DEFINITION

280.] The term cysticercosis is applied here to that form of somatic taeniasis caused by the development in man of cysticercus cellulosae, the bladder-worm stage of the tapeworm *Taenia solium*. Although the beef tapeworm *T. saginata* is much commoner than *T. solium*, there appears to be no conclusive record of human cysticercosis due to it.

2.-AETIOLOGY

The adult *T. solium* is a parasite of man only, and as a rule the larval stage is passed in swine, the parasitized flesh being known as 'measly pork'. The occurrence of 'measles' in swine shows that the disposal of

human dejecta is such as to allow of the infection of these animals by tapeworm eggs; the presence of *T. solium* in the human intestine points to ineffective inspection and cooking of pork.

Incidence

At a time when the low standard of sanitation necessary for the development and transmission of *T. solium* prevailed in Europe, cysticercosis was frequent, notably in parts of Germany where uncooked ham was a popular food. Following on Leuckart's classical researches in Germany, Cobbold, some seventy years ago, studied cysticercosis in England and recorded a number of cases of the disease, but doubtless, as can always be said of cysticercosis, for every case detected many passed unobserved. After Cobbold's day the disease in Britain lapsed into obscurity and in general was forgotten by the practising physician, such cases as were recognized being regarded as curiosities of medicine, and of little interest except to the parasitologist. Of late years, however, cysticercosis has been brought into prominence by the discovery that epilepsy developing in British soldiers during or after service abroad is commonly due to this disease. In the majority of these cases infestation originates in India where most soldiers serve their term of foreign service, but the disease is not limited to that country, or to the British soldier, and may be contracted wherever *T. solium* is found, and especially if a primitive system for disposal of faeces co-exists.

*Inspection
of pork*

There are two practical points which those concerned in the prevention of cysticercosis must bear in mind. No form of pork inspection which is ordinarily possible can be relied on to detect a sparse infestation with cysticerci, and museum specimens of measly pork honey-combed with cysts give a wrong impression of what may be encountered. In a laborious experimental dissection of two pig carcasses passed as fit for food, W. K. Morrison in India discovered three cysticerci in one, and nine in the other. In contrast to this, the same observer on another occasion found eight complete cysticerci in one pork sausage. So that however carefully pork may be inspected by the means available, thorough cooking before it is eaten is essential. The second point is that wherever *T. solium* occurs the true incidence of infestation with the adult will always exceed the number of cases detected, for with certain tapeworms, including *T. solium*, the segments may either be digested completely, or passed in a form unrecognizable to the naked eye. Leiper, from his experience of a personal experimental infection with *Dibothriocephalus latus*, found that for over a period of five years no segments were passed in the faeces although eggs were present, and at the end of this period three adult *D. latus* were removed by ant-helmintic treatment. He also observed that even if segments of *T. solium* are present they may easily be overlooked, for they may be semi-digested and indistinguishable from mucus even to an expert, unless the apparent mucus is examined with the microscope.

3.—DEVELOPMENT OF CYSTICERCUS CELLULOSAE IN MAN

Taenia solium produces eggs in enormous numbers, each mature segment containing some 40,000, so that the host of a tapeworm may void several hundred thousand eggs at one time. Infestation of man by cysticercus cellulosae occurs through the accidental ingestion of tapeworm eggs which may be conveyed by food, water, or flies, uncooked vegetables and some ground-fruits being especially dangerous. The host of a tapeworm may contaminate his hands with eggs and in this way bring about infection either of himself or of others, or, as has been suggested, auto-infection may result from the regurgitation of tapeworm segments into the stomach of the host. By whatever means the eggs enter the alimentary tract of man, their development proceeds as in the usual intermediary host, the pig. The liberated embryos penetrate the intestinal mucosa and are borne by the blood-stream to their final habitat, the site of which is determined by the active movements of the parasites and not by mechanical means. In man they have a predilection for the brain and musculature, the heart is often involved, sometimes the lungs and kidneys, and rarely the liver; indeed, they may be found in any organ or tissue except, it is said, bone. The parasites may lodge in any part of the brain—meninges, cortex, basal ganglia, ventricles, or white substance; but in general grey matter is invaded more commonly than white. The belief that there is a special selection of the eye appears to arise from the fact that invasion of this organ, unlike invasion elsewhere, is not likely to be overlooked. In the eye the parasite lodges most frequently beneath the retina and with growth may burst through the tissues and be seen moving actively in the posterior chamber; or, by a like process, one may appear in the anterior chamber.

Infection

*Migration of
larvae*

The total number in the body may vary from one single cysticercus to many hundreds, according to the number of eggs swallowed, for multiplication does not take place in the host. Infestation may be limited to the brain, and even with as many as 200 or 300 cysticerci in this organ, the most careful search at necropsy may fail to demonstrate any elsewhere.

*Number and
distribution
in body*

The morphological development of cysticerci is completed within three or four months, though thereafter they may increase in size. Except in the brain the cysticerci become walled off by a clear-cut fibrous capsule in which two layers can be distinguished, an outer highly cellular layer, and an inner in which the connective tissue is condensed and homogeneous in appearance with few nuclear elements. The effect of the encapsulation is to protect both the parasite and the host. It is difficult to give a comprehensive account of the changes brought about by the invasion of the brain, for the nature and intensity of these vary with the age and condition of the parasite, and even in

*Formation
of capsule*

the same brain differ widely in degree. In general, a tissue response on the part of the host results in the encapsulation of the parasite, but in the brain the enclosing wall is more extensive and less well defined than elsewhere in the body.

*Formation
of capsule
in brain*

An examination of a series of eight human brains in which parasites had been present for periods of from six months to sixteen years,

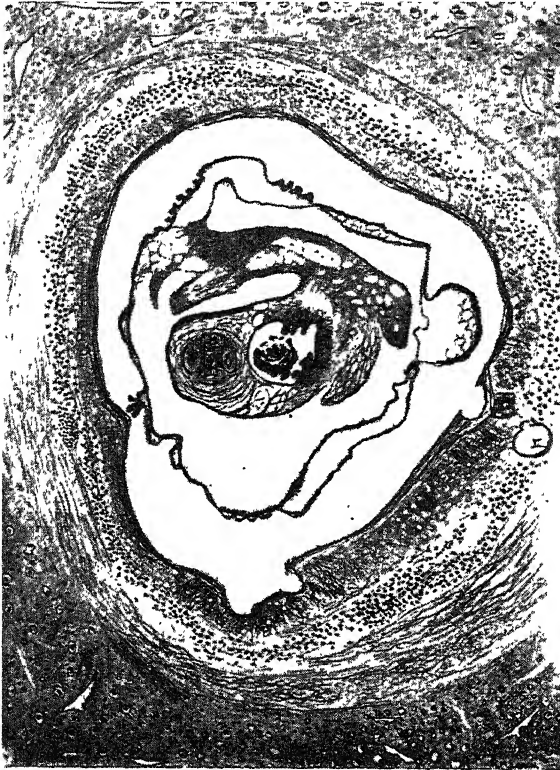


FIG. 64.—Human brain containing an undegenerated and seemingly living larva of *Taenia solium*. Infestation of not less than 15 years' duration. Note scolex with suckers and hooklets, and collapsed bladder-wall. The reactionary zones in the brain tissue are clearly shown

indicated that, following an initial destructive lesion, encapsulation results from a proliferation of neuroglial tissue, accompanied by a cellular reaction—mainly of small round cells, plasma cells, and endothelial cells—so marked as to form a defined zone. Through the increasing pressure exerted by the parasite the neuroglial tissue becomes sclerosed, with a consequent disappearance of the nuclear elements. Outermost and adjoining the normal brain there is an area of delimiting gliosis very variable in extent and degree. Unless the larvae overwhelm the brain by their numbers or lodge in some par-

ticularly vulnerable site, a relative balance seems to be attained between the encapsulated living cysticercus and the living tissues of the host, so that both exist together in what may be regarded as a form of symbiosis. But sooner or later the cysticercus dies and acts as a foreign irritant, liberating toxic substances in the process of degeneration, and exerting pressure through an increase of fluid associated with its death. The changes in the parasite provoke a cellular reaction, the elements of which later become involved in the general lysis affecting the parasite and the surrounding tissues. The

damage to the cyst capsule—sometimes amounting to necrosis—permits the penetration of toxic elements to the surrounding brain, as evidenced by destructive changes which may be traced far into its substance. If the host survives, the dead tissue becomes isolated by a further process of encapsulation. A terminal calcification, although

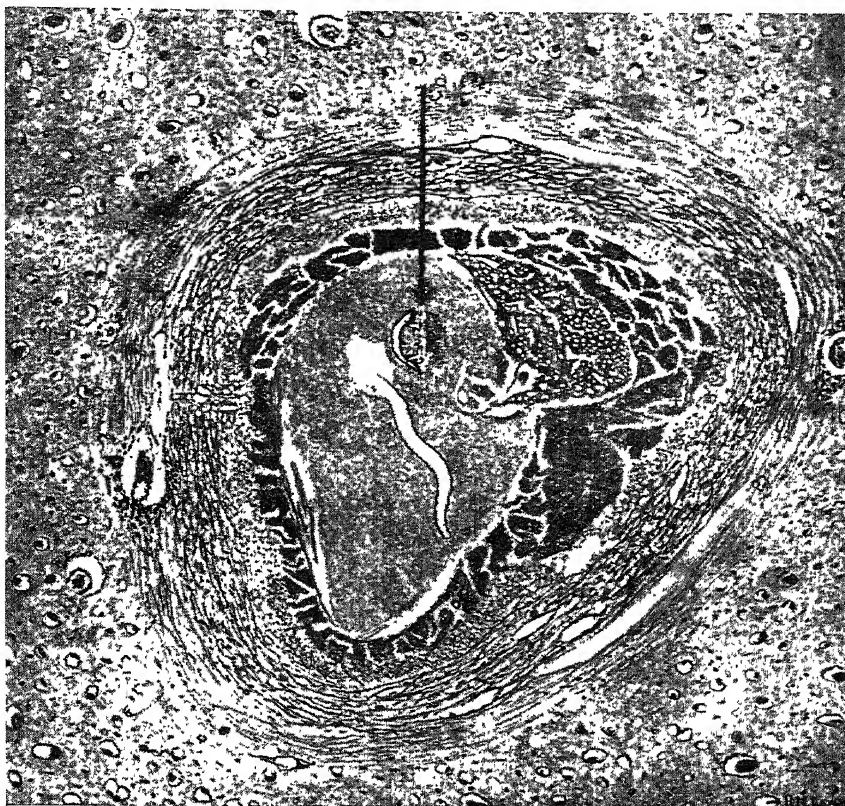


FIG. 65.—Human brain containing a dead and degenerating larva of *T. solium* (showing hooklets, indicated by arrow). Infestation of less than 1 year's duration. Note areas of necrosis affecting both parasite and host tissues with intense cellular reaction beyond, and involvement of brain tissue spreading outwards

common in the body generally, is exceptional in the brain (see Figs. 64 and 65).

In the brain of one man who died in status epilepticus supervening on major epilepsy which had persisted for six years, parasites in three main contrasting stages were found: living and relatively quiescent cysticerci which, it is suggested, held potentialities for later mischief, had the patient not succumbed; others, degenerating and surrounded by active destructive changes, and presumably responsible for his death; and thirdly, remnants of lysed parasites which with the neighbouring necrosed tissue had undergone a secondary encapsulation and would appear to have caused the earlier symptoms.

The foregoing interpretation of the pathological findings appears to explain the following clinical observations: that commonly a long quiescent interval elapses before brain symptoms become evident, and over 100 parasites may be lodged in the brain for at least six years before giving any outward signs of their presence there; that when brain symptoms develop they are subject to periods of exacerbation followed by intervals of relative or absolute quietude; and that the symptoms in an individual case may alter markedly both in their character and in their localization during the course of the disease, pointing to successive stages of intensifying and diminishing irritation in different parts of the brain.

*Duration
of life of
cysticerci*

The duration of life of individual cysticerci varies within wide limits; as a rule they die off gradually so that calcified cysts and living parasites may co-exist in the same host. Some indication of their longevity is given by that curious feature of the disease—the continued appearance of subcuticular cysts in persons who are known to have suffered from cysticercosis for years. Thus, one subject of cysticercal epilepsy showed no palpable cysts for four years; then one appeared, followed by several others during the fifth and sixth years; he was kept under observation in the seventh year, and during this period sixteen ‘new’ cysts were detected. This phenomenon is explained by the increase of cyst fluid which accompanies the death and early degeneration of the larva, so that cysts previously flaccid and imperceptible become tense and hard. From observation of such cases it appears that many parasites die off between the third and sixth years, though viability far beyond this period is possible. Calcification sufficient for detection in a radiograph points to death of the parasite at least three years previously.

4.—CLINICAL PICTURE

In order to understand the course of the disease, it must be realized that the biological object of the larvae, when once established in the intermediate host, is to remain quiescent while they await an opportunity of completing their development in the alimentary tract of the definitive host—an end impossible to achieve in human cysticercosis unless cannibalism is practised. To the cysticerci, the death of the host is a calamity for it involves their own destruction, and if cysticercosis in general were a killing disease, *Taenia solium* would become extinct.

*The acute
form*

Sometimes the embryos invade the brain in such large numbers that the intensity of the reaction they provoke is incompatible with the survival of the host, and the symptoms of this stage of infestation, which otherwise are usually mild and transient (or altogether absent), are of great and increasing severity, and the period of the early development of the cysticerci constitutes the whole course of the disease. Death may result within a week of the onset of symptoms, the general picture resembling that of acute encephalitis. Or, in a less acute form, the

patient may live for several months, with irregular initial fever, headache, and other signs of increasing intracranial pressure, including papilloedema, motor and sensory changes, and deepening mental stupor ending in coma and death. In attacks of the acute and subacute type, the most characteristic signs of cysticercosis—subcuticular cysts and major epileptic attacks—are not found, for the reason that the duration of life is too short for their development.

An infestation which follows what can be regarded as a normal course may be divided into two or three arbitrary but convenient clinical stages: (1) the incubation period; (2) the period of premonitory symptoms; and (3) the established disease. *Normal type of infection.*

The incubation period is the interval between invasion by the embryos and the onset of symptoms. The time when infestation took place is usually difficult to determine. In a majority of cases there is no history or other evidence of preceding intestinal taeniasis. Even if a patient is known to have harboured an adult *T. solium* and is therefore presumed to have acquired cysticercosis by auto-infection, it is often impossible to know how long the tapeworm may have been present before it was detected. Some patients have shown symptoms of cysticercosis while in hospital undergoing treatment for a tapeworm recently discovered; in other cases there has been an interval of several years between the complete expulsion of a worm and the eventual development of clinical cysticercosis. It is unusual for a patient to show symptoms of what here is called the established disease within two years of going abroad. *Incubation period*

The period of premonitory symptoms is the period of clinical response to the disturbances set up by the invasion and active development of the parasites. In many instances this process gives rise to little general reaction, and as a rule such symptoms as may be caused are so mild and indefinite that their significance is appreciated only when the later characteristic signs of the disease have become apparent. There may be a record of the occurrence of headache and unidentified fever, or of an attack of what was regarded as myalgia, during any of which a transient eosinophilia may have been detected. Occasionally the invading parasites provoke a condition of oedematous swelling, localized or general, of the muscles that later are found to harbour cysticerci. *Period of premonitory symptoms*

On the other hand, the latent period which commonly precedes the onset of the classical disease—and which can extend to as much as twelve years—may be undisturbed by any early premonitory symptoms. Many subjects of cysticercal epilepsy who show evidence of an infestation of long standing when the first seizures develop, declare that prior to the onset of fits they ‘never had a day’s illness’, and never missed a game of football or hockey, or any other strenuous exercise for reasons of health.

When the disease is established, the most characteristic sign and the most helpful in diagnosis is the appearance of subcuticular cysts in the tissues, singly or in crops. Not only does the number of these cysts *The established disease*

vary widely in different patients, but it also alters in the same patient from time to time. Cysts that have been in evidence for several years may collapse and vanish within a few days, and others, through the

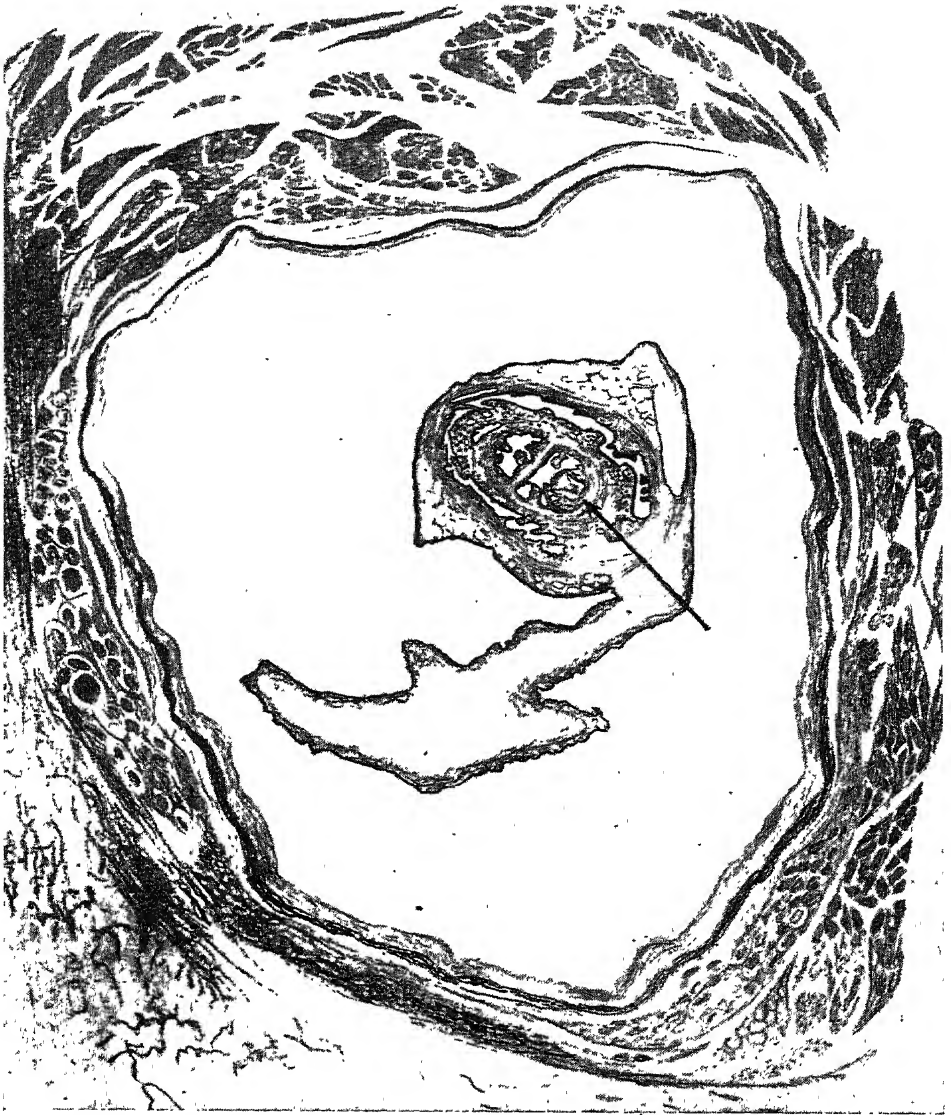


FIG. 66.—Human muscle, containing a larva of *T. solium* (showing hooklets, indicated by arrow). Note scolex with collapsed bladder-wall, and beyond, the host capsule consisting of two layers of fibrous tissue

death of the contained parasite, appear in sites where previously none could be detected on the most scrupulous examination. Because of this coming and going, patients often imagine that the nodules migrate from place to place.

Palpable cysts may be found in the muscles or in the subcutaneous tissues of any part—the head and face, including eyelids, lips, and tongue, the trunk and limbs, but rarely in the hands and feet, though these parts are liable to invasion as may be demonstrated in radiographs. They appear more commonly in the upper half of the body, not because the parasites are more numerous there, but because of the better cover afforded by the larger masses of muscle in the lower half. The size varies with their age and situation. If in tissues which are equally resistant on all sides, the cysts tend to be rounded, as in the substance of the brain where a diameter of 10 or 12 millimetres is an average measurement. In the muscles they are oval in shape and lie between the fibres which they separate, and when fully grown they may attain a length of 20 millimetres or more. When palpated in muscle they often appear about the size of a bean but may seem as small as a pea, or if in soft muscle, as large as a pigeon's egg. The number that can be made out in an individual case may vary from a single cyst to several dozen, and typically there are no subjective symptoms to bring them to notice.

*Palpable
cysts*

It must be understood that palpable cysts are not a constant feature of the disease; the brain may be invaded and the musculature remain free; even when radiographs show many calcified parasites in the muscles there may be no history of preceding palpable cysts at any time.

The commonest presenting symptoms of cerebral involvement are epileptic seizures, which usually develop only when an infestation has lasted for several years. The attacks may show all the stages and features of major epilepsy, and reproduce the classical picture so closely that a subject of cysticercosis has remained under medical observation, both as a private and as a hospital patient, for periods totalling twenty-two years without the diagnosis of 'idiopathic epilepsy' having ever been questioned. Or the attacks may be of a Jacksonian type, with or without loss of consciousness, or may resemble petit mal. In some instances they are irregular in character and lack any clear-cut sequence of stages.

*Symptoms of
cerebral
involvement*

Sometimes in Jacksonian attacks there are peculiarities which are themselves suggestive. Successive fits affecting a patient may each begin in a different muscle group, suggesting multiple lesions; or, a patient whose initial spasm has for years commenced in some particular part (e.g. the right hand) may show a complete transference of the initial spasm to another site (e.g. the left foot), thus suggesting a diminution of irritation in one area of the brain and an intensification in another.

There may be a long history of occasional localized muscular spasm—often regarded as hysterical—prior to the onset of fully-developed major attacks. Thus, a person who appears otherwise normal may suddenly for a few seconds flex his wrist, clench his teeth, or bend his neck, being quite aware of the movement but unable to control it. The contractions are usually constant in type and site in each person so affected, and may recur at intervals of weeks or months for one or more years. Then without further warning the subject may fall unconscious and pass through a series of violent major fits in quick succession.

The onset of epilepsy may correspond in time with the first demonstrable appearance of cysts. In other cases there is a long latent period—which may amount to at least six years—between the detection of subcuticular cysts and the first epileptic seizure; or this order may be reversed and epilepsy may persist for several years before any cysts become evident.

The other signs of cerebral involvement are less dramatic than epilepsy, but they cover an extraordinarily wide range. Since larvae may develop in almost any part of the brain, symptoms—motor, sensory, or mental—which result from any focal lesion in that organ can be produced in cysticercosis. The picture may be that of cerebral tumour with all or any of its classical features, or may resemble disseminated sclerosis, or, if a heavy infestation exists, acute encephalitis.

*Psychical
disturbances*

Psychical disturbances with or without associated fits may predominate at times, and the considered diagnoses made in cases which later proved to be cysticercosis have included hysteria, neurasthenia, melancholia, acute mania, delusional insanity, and dementia praecox. Besides gross psychical symptoms sufficient to suggest diagnoses such as some of the foregoing, there may be evident mental dullness, impairment of memory, periods of disorientation, or a change in disposition, so that a person originally efficient and alert becomes careless and untrustworthy.

The foregoing symptom-groups represent mere phases or stages of the infestation, and their character and extent are determined, as I believe, by the waxing and waning of parasites in different parts of the brain. It has been a custom to divide cysticercosis into a large number of clinical 'types' which are named according to the character of the presenting symptoms. This misleading representation betokens a limited first-hand experience of the disease, for if cases are kept under prolonged observation they can be assigned to one of the described types at one stage and to a different type at another; and a patient when observed from first to last may be seen to pass through every one of the so-called types of this protean disease. An early note in a case-sheet emphasizing the absence of fits may be followed by a final note recording the patient's death in status epilepticus.

5.—PROGNOSIS

Prognosis is extremely difficult as no method exists for ascertaining during life the number of cysticerci in the brain and their distribution there, or of forecasting the degree of reaction which they may provoke later. If a subject of cysticercal epilepsy who exhibits only occasional major attacks were kept under observation, his future history might follow any of the following courses: cessation of fits, and clinical cure; continuing fits, the patient remaining mentally alert; continuing fits with mental deterioration of any grade from impairment of memory to some state necessitating certification; continuing fits with progressive

sensory and motor changes such as pareses or paralyses of limbs and aphasia, with or without accompanying mental degeneration; development at any time of status epilepticus.

The general tendency of the disease is one of retrogression and the most dangerous time is from about the sixth to the eighth year of the duration of symptoms, for then the grave intensification of existing cerebral disturbances most frequently takes place, and subjects who have remained free from outward signs of an extensive brain involvement are most likely to show them about this time. On the other hand, in some instances the fits come to an end after having persisted, as in the military series, for periods ranging from a few months to twenty years.

6.—DIAGNOSIS

As is the case in many other maladies, the great impediment to the recognition of cysticercosis is failure to think of the disease actually present, and until recently, for this reason, patients presenting the most characteristic signs of cysticercosis could be shown at examinations for higher degrees in medicine in full confidence that none of the qualified and experienced candidates would either diagnose the condition or mention it in the written discussion of the case as a possibility even remote.

Cysticercosis should always be considered when, without evidence of any foregoing epileptic taint, there is an onset of epileptiform attacks in an adult, especially one who has resided abroad, for in Great Britain *T. solium* is rare and cysticercosis, though possible, is not likely to be acquired there. If with this suggestive history there is no convincing evidence of any alternative cause for the fits, a systematic investigation for cysticercosis becomes imperative. It should be emphasized in this connexion that, after idiopathic epilepsy, the condition for which cysticercosis is most frequently mistaken is cerebral tumour.

During the life of the host diagnosis for practical purposes depends on only two points, neither of which, unfortunately, represents a necessary stage in the development or the degeneration of the cysticercus—the appearance of detectable cysts in the tissues, and the calcification of dead parasites. The patient under suspicion should be examined systematically from head to foot for cysts, the muscles being palpated by kneading and rolling movements while in different stages of contraction and relaxation, and the surface of the body inspected in varying positions relative to the source of light. Even if parasites have lodged in the muscles, they may be either too deep for detection or so few as to escape notice; or the host may come under examination when he is free from palpable cysts although these may have been present months or years before, or may appear months or years later. A patient should always be questioned on this point, for he may previously have noticed cysts which are no longer in evidence, or at the time of examina-

Palpation

tion he may be aware of 'little lumps' in some part, and if these are deep-seated and difficult to detect he may demonstrate some digital manœuvre by means of which they can be felt. In the absence of present evidence and past history of cysts, their characters should be described in simple language and the patient warned to watch for any such appearances.

*Diagnostic
excision of
cyst*

In order to demonstrate the parasite, a suitable cyst is removed under local anaesthesia. The host capsule is incised carefully and the enclosed cysticercus gently extracted. The appearance of the translucent membrane with its central or terminal 'milk spot' (representing the invaginated scolex) is characteristic. Calcareous corpuscles—small, clear, refractile bodies—are normally present both in larval and adult tapeworms, and when seen in cysticerci must not be taken as evidence of a degenerative calcification.

The diagnosis in cysticercosis is easily established when there are palpable cysts; the disease, however, is no less likely if they have been absent throughout; and if in any considerable series of patients they are recorded as being always present at some stage, it may be assumed that many cases of infestation are being overlooked.

*Radiographic
diagnosis of
calcified cysts*

I am indebted to W. K. Morrison for the following notes on radiological examination: 'For routine investigation the following regions are radiographed: skull, lateral view only; root of neck; upper arms; fore-arms; thighs; legs. The films and the intensifying screens should be free from "grain". The standard of radiograph aimed at in each region should be that of the ordinary exposure conditions for bone detail, with a very slight under-exposure. Radiographs taken to demonstrate soft tissues are useless. The parasite may be represented by a final radiopacity in any form from the calcified scolex (about one millimetre in diameter) up to a fully-grown elliptical cyst (about twenty-three millimetres long). Radiographs are viewed in the ordinary way, but owing to the faint shadow produced by the early calcifying parasite, the search of the soft tissues must be very thorough. It is quite easy to miss a small section of a calcified parasite at the upper or lower margins of the films, or to miss one overlying normal bone shadows. Oblique illumination is sometimes of value. If single shadows are observed, the patient's skin should be examined for the presence of warts, scars, or red ink tattoo marks. The shadows often imitate simple film stains, and in case of doubt the radiograph should be repeated. Films should be filed for comparison with those taken at a later date.'

It is scarcely necessary to add that the radiologist should familiarize himself with the structure of cysticerci and their developmental history in the body.

Calcification occurs only as a form of post-mortem degeneration, and about three years generally elapse between the death of a cysticercus and the deposition of calcium sufficient for recognition in a radiograph. As already mentioned, some parasites may die early, while others in the same host may remain alive for many years, and, speaking generally,

a positive radiograph can hardly be expected if the patient's symptoms are of less than four or five years' duration. On the other hand, if the silent stage of the disease has extended, say, to over five years, calcified parasites might be found somewhere in the body at the time of the onset of nervous symptoms.

If no signs of calcification can be detected in a thorough scrutiny of the films, the patient should be put back for re-examination, but with definitely negative radiographs a positive result is unlikely within a period of less than a year or eighteen months.

It cannot be too strongly emphasized that as a rule the cysticerci in the brain do not calcify, and so cannot be seen in a radiograph; radiological examination, therefore, should never be limited to the skull. When, as occasionally happens, calcification in the brain results, the cysts usually show as small rounded shadows, suggesting pickles of shot. Calcification in the pituitary or pineal gland should not be mistaken for a cysticercus; a more common radiological error has been to identify cysticerci as *Trichinella spiralis*. The confusion will not arise if it is remembered that in trichinosis the shadows of the calcified cysts are so minute as barely to be visible in a film without magnification.

Blood counts give little help in diagnosis. During the stage of invasion an eosinophilia may be present but even in acute attacks is not constant. In the established disease, owing no doubt to the encapsulation of the parasites, the eosinophil count is usually normal. At a later stage when the cysts are breaking down and liberating their contents an eosinophilia may recur. *Blood counts*

There are no constant changes in the spinal fluid, and such deviations from the normal as may be met in certain cases have no positive diagnostic significance. The spinal fluid may be under increased pressure, or show signs of a cellular reaction, usually lymphocytic, but even in the presence of profound cerebral disturbance the spinal fluid may remain unaffected. None of the military series of cases showed an eosinophilic response in the spinal fluid. The Wassermann test, unless there is accompanying specific disease, is negative. *Spinal fluid*

The results of complement-fixation and skin tests, using as an antigen an alcoholic extract of *T. solium*, have been disappointing, and when tried in proved cases of cysticercosis a negative result is more common than a positive. The tests are not specific, for they embrace the whole taenia group, but whereas a positive skin reaction might result from the presence of an adult tapeworm in the intestine, a positive complement-fixation reaction points to somatic invasion. In spite of the worthlessness of a negative result, the complement-fixation test may be most helpful on occasion. Thus, positive readings were obtained in the case of two ex-soldiers supposed to be subjects of idiopathic epilepsy, these results being unsupported at the time by any other ascertainable evidence of cysticercosis. Later one of the men developed subcuticular cysts, and in the other case a positive X-ray picture was forthcoming. *Complement-fixation tests*

One important point in diagnosis should be stressed. A liability to

'fits' is a heavy handicap in the labour market and therefore men not infrequently conceal their disease, and when questioned deny strenuously that they ever suffered from fits or cerebral symptoms of any kind. The case of one such man—in whom calcified cysts were accidentally discovered in an X-ray examination of an injured ankle—was published as an example of extensive cysticercosis without cerebral symptoms. Finally, after a long enquiry by H. B. F. Dixon, it transpired that the man was an old soldier and had originally been invalided from the army for persistent 'major epilepsy'.

Cases of possible cysticercosis should be kept under observation, re-examined from time to time, and subjected to radiological investigation at intervals of one or two years. No series of negative examinations and tests, however thorough and complete, can rule out cysticercosis, and the longer the period of observation and the more painstaking the repeated searches for parasites, the larger will be the proportion of suspected cases in which proof of infestation is eventually found. It is not sufficiently realized that for every case of cysticercosis readily diagnosable there is a large number which defy diagnosis for years, or which can be recognized only at necropsy; and even after death the presence of a few cerebral parasites—perhaps only one or two in all—might easily be overlooked unless the pathologist has cysticercosis in mind, knows what to look for, and leaves no scrap of brain tissue more than 4 millimetres square, unsearched.

7.—TREATMENT

Phenobarbitone (luminal) or one of the inorganic bromides is often helpful in controlling fits, but no medical treatment employed so far has had any curative effect. Indeed the observations on tissue changes consequent on the death of intracerebral parasites suggest that if any parasitocidal substance were forthcoming it should be employed with caution, for the destruction of large numbers of parasites simultaneously might well make matters worse for the sufferer, unless possibly the treatment were adopted soon after infection and before the cysticerci had attained larval maturity.

The numerous parasites commonly present in the brain and their wide distribution there contra-indicate a general resort to surgery. Operation is justifiable only when some restricted and constant localizing sign is present (e.g. aphasia), or in certain cases as a general measure to ameliorate grave symptoms of increasing intracerebral pressure. It is important to remember that muscular spasm when confined to some particular part does not necessarily indicate a limited cortical involvement.

The successful removal of cerebral cysts is occasionally reported in medical literature, but before claiming a cure or appraising the degree of permanent improvement time must be given for any other parasites in the brain to die off, and this may mean years of observation. In actual

experience a temporary amelioration after removal of one or more cysts has been followed by a recurrence of symptoms ending in death.

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CYSTINURIA

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Reference may also be made to the following titles:

BLADDER DISEASES HEREDITY AND CONSTITUTION
 URINE EXAMINATION

1.—DEFINITION

281.] Cystinuria is an abnormality of metabolism resulting in the presence in the urine of the amino-acid cystine—[S. CH₂. CH(NH₂). COOH]₂—or of some chemical precursor of it which decomposes in the urine and liberates free cystine.

2.—AETIOLOGY

The biochemical disorder which results in the excretion of cystine has been recognized only as a familial or a congenital fault, and falls into that group of diseases termed by Garrod 'The inborn errors of metabolism'. Its mode of inheritance indicates that it is transmitted as a recessive Mendelian character, and this fact accounts for the great variation of its incidence amongst the members of affected families.

Mode of inheritance

A remarkable history of the disorder in the progeny of two half-brothers is reported by Thin. The elder half-brother, himself free from cystinuria,
 538.

had twelve children of whom seven were cystinurics. The younger half-brother had ten children all free from cystinuria. Three of these children of the younger half-brother married their cousins, the elder half-brother's children, of whom two had cystinuria and one had not cystinuria. The progeny of two of these marriages were affected with cystinuria, one of the marriages being that between the non-cystinuric cousins.

The distribution of the disorder is very irregular and depends upon the distribution of cystinuric families; but in a mixed western population it has been estimated as occurring in from 1 in 35,000 to 1 in 10,000 persons. It affects males and females and has been discovered both in oriental and occidental races. It has been reported in infancy, childhood and adult life, but when discovered late in life the probability is that it has been present since birth. *Incidence*

3.—CHEMICAL PATHOLOGY

Cystine is one of the normal amino-acid constituents of protein and is obtained in greatest amounts from the keratin-containing tissues. One of its chief chemical characteristics is that it contains sulphur, a fact which facilitates its detection in calculi. In the normal processes of metabolism, cystine is derived from protein and is then broken down to simpler constituents, urea and inorganic sulphates, which are excreted in the urine.

At first sight it would appear that the error of metabolism which leads to the excretion of cystine was a failure on the part of the body to break down ingested protein to its simple end-products so that cystine remains to be passed in the urine. But this is not so, for experiments have shown that if cystinurics are fed with excessive amounts of cystine there is no increase in the amount of the substance excreted in the urine. This suggests that the cystine is derived from the breakdown of endogenous tissue proteins, and Brand has advanced the explanation that its excretion in the urine results from an increased renal permeability to cystine or a cystine-forming compound, and that it is thus similar to the glycosuria of renal glycosuria. *Pathogenesis*

The formation of cystine calculi is a prominent clinical feature of the disorder. The manner of their formation has not been fully elucidated. Preceding infection of the urinary tract does not explain it, for the urine may remain sterile in the continued presence of cystine calculi; on the other hand there have been cystinurics with infected urine who have remained free from stone. Cystine is soluble in alkalis, and crystallizes out slowly after the urine has been acidified with acetic acid. It is generally assumed therefore that the hydrogen-ion concentration of the urine is the determining factor in the formation of cystine calculi, and it is on this theory that the preventive treatment by alkalinizing the urine is based. *Cystine calculi*

4.—CLINICAL PICTURE

Cystinuria in itself is a symptomless disorder which often persists throughout life without ill effects. The chief danger lies in its tendency to form urinary calculi, of which the symptoms do not differ from those of other forms of urinary calculi and which therefore do not require special consideration here. But since it has been erroneously thought that cystine calculi are always unilateral and frequently fail to reveal a shadow on X-ray examination, it must be emphasized that they are often bilateral and usually opaque to X-rays.

Albuminuria associated with cystinuria has been reported by Hickmans and Smallwood, who observed in two sisters an albuminuria which fluctuated with the rise and fall in the amount of cystine excreted.

5.—COURSE AND PROGNOSIS

Since cystinuria itself is symptomless and free from danger the course and prognosis depend entirely on the formation of cystine calculi and the ill results which may arise therefrom. It is estimated that calculus formation occurs in less than 10 per cent of cystinuric patients. It is usually in adolescence or early adult life that the stones appear, and after their removal there is a tendency for them to recur. This carries the risk of ultimate calculous pyonephrosis, so the final prognosis must always remain in doubt.

6.—DIAGNOSIS

Examination of crystals

In symptomless cystinuria the diagnosis turns on the detection of cystine by examination of the urine. The most reliable method is the discovery or preparation of cystine crystals from the urine (see Fig. 67). The crystals are almost colourless, with a glistening or waxy appearance, and are seen as completely hexagonal plates. They should be sought in urine which has been acidified with acetic acid and allowed to stand for several hours. If this method fails, the urinary deposit should be dissolved in ammonia, and the solution then allowed to evaporate on a slide until the crystals appear.

Cyanide nitroprusside test

The simplest chemical test is the cyanide nitroprusside test. To 5 c.c. of urine add 2 c.c. of a 5 per cent solution of sodium cyanide and allow to stand for five minutes. Then add a few drops of a 5 per cent solution of sodium nitroprusside. Cystinuric urines give a characteristic stable magenta colour. For more elaborate but specific tests, and for the quantitative estimation of cystine, Brand's description of Sullivan's method should be consulted.

The diagnosis of cystinuria may in many cases be made by examining

the urinary calculi and discovering cystine in them, either by chemical tests or by the preparation of crystals after dissolving the powdered stone in ammonia.

The most important clinical feature in the diagnosis of cystinuria is a history of familial tendency to urinary calculi. In all such cases chemical tests and a search for the crystals should be made to reach a diagnosis. Indeed, it is a reasonable clinical procedure to test all calculous patients in this way; for on recognizing that a patient is a cystinuric, treatment

*Family
history*

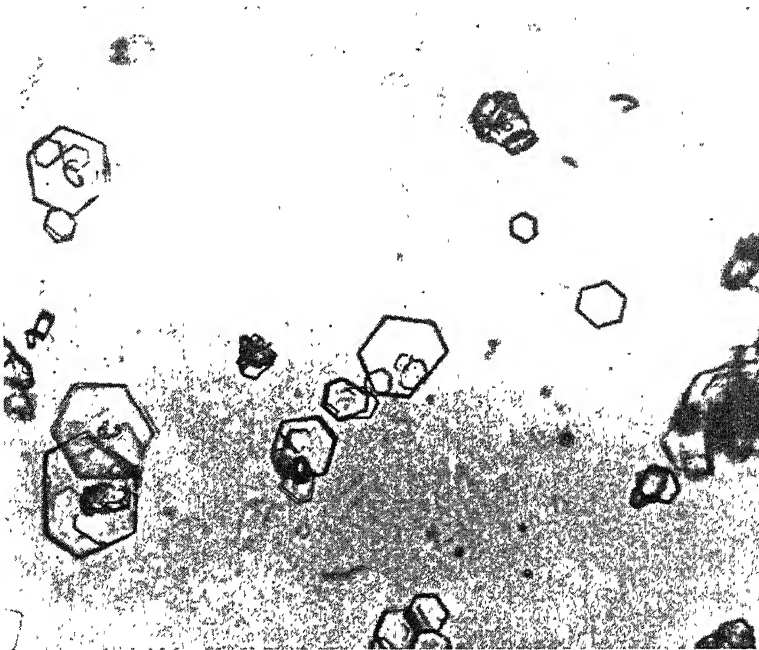


FIG. 67.—Photomicrograph of cystine crystals $\times 400$

can be given with a view to the prevention of further calculi. Many cases are recorded of single cystine calculi being successfully removed by operation without further formation of stone.

7.—TREATMENT

Cystinuria is an inherited fault which cannot be altered by treatment. The best that can be done is to try to prevent the formation of stones. To achieve this most authors emphasize the importance of low protein diet, but since cystine would be formed from endogenous sources even if protein were withdrawn entirely from the diet, there is nothing to be gained by reducing the protein of the diet below the physiological requirements of 80 to 90 grams a day.

To prevent the formation of cystine calculi, patients should be advised

to avoid those trades and environments which lead to concentration of the urine. That they should lead regular and temperate lives is more than a mere platitude, for these patients should try to prevent wide fluctuations in the reaction of their urine. The aim should be to keep the urine neutral or slightly alkaline and for this purpose sufficient sodium bicarbonate should be given two or three times each day. Careful observations by Patch have cast doubt upon the claim that cystine stones can be dissolved by strong alkalization of the urine. In view of the tendency to recurrence of stones it is not surprising that the wisdom of surgical interference is questioned, but it is obvious that removal of stones by operation may be necessary for the same reasons as it is in the treatment of other forms of calculi.

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CYSTITIS

See BLADDER DISEASES, Vol. II, p. 396; *and*
COLIFORM BACILLUS INFECTIONS, p. 287

CYSTS

See DERMOID CYSTS, p. 635; DESMOID TUMOURS,
p. 637; TERATOMAS; *and* TUMOURS

DACTYLITIS

See BONE DISEASES, Vol. II, p. 576; *and*
HAND, DISEASES AND DEFORMITIES

DARIER'S DISEASE

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Reference may also be made to the following title:

ACANTHOSIS NIGRICANS

1.—DEFINITION

(*Synonyms*.—Psorospermiosis follicularis vegetans (Darier); keratosis follicularis (C. J. White); dyskeratosis follicularis (Darier))

282.] Darier's disease is a relatively rare condition of the skin becoming, however, increasingly more often observed; it is characterized clinically by the presence of crusted papules (Darier), usually occupying the orifice of the pilo-sebaceous follicles, and histologically by the presence of round bodies ('corps ronds' of Darier) in the stratum mucosum of the epidermis. The eruption is distributed symmetrically, and may eventually cover large areas of the body. The papules may coalesce to form warty sheets and tumours with occasional ulceration. The continuous development of the disease is seldom modified by any treatment yet devised, but the prognosis as regards life is benign. Its causation remains entirely unknown; a recent suggestion that it is a naevoid manifestation is under examination.

2.—AETIOLOGY AND MORBID ANATOMY

The disease has aroused more interest than its intrinsic importance *Historical* would seem to justify because of earlier phases in its observation, and very notably because of the suggestion, made initially by Darier, that the 'round bodies' which he was the first to describe were parasitic organisms (*sporozoaires*) and were of the same character as the similar 'round bodies' found in Paget's disease of the nipple, furnishing thus



FIG. 68.—Drawing of microscopical section of the skin in Darier's disease showing the characteristic 'round bodies' in the epidermis
(From *A System of Medicine*, edited by Allbutt and Rolleston)

an unexpected link between a uniformly benign and a uniformly malignant skin disorder, and, a more important consideration, affording support, as it seemed, for the parasitic origin of cancer.

The priority of description has been disputed. The facts are probably as follows. The title 'keratosis follicularis' was first used by Prince Morrow to describe a case which is rather difficult to classify, but may have been the first example of this disease to be clinically and histologically described. Thibault, working with Darier and under his direction, published in May 1889 a degree-thesis giving the clinical description of two cases which he styled *psorospemose folliculaire végétante de Darier*. In July 1889 Darier completed Thibault's clinical

description and added his own histological observations. In this communication Darier gave the first description of 'cells in the epidermis with the appearance of bodies entirely round' (*corps ronds*), 'surrounded by a glistening membranous envelope with a double contour', and he gave reasons for regarding these bodies as parasitic organisms. In the light of later developments it is interesting that in this paper he stated expressly that it was 'quite impossible to see in these bodies epithelial elements which have undergone any known process of degeneration or even any special form of degeneration'.

In June 1889 C. J. White described, under the name 'keratosis follicularis', a case which has been accepted as being the same disease as Darier's psorospermosis. White was unaware of Darier's cases but regarded Morrow's case as of the same nature as his own.

Darier, in 1896, acknowledged his early mistake in regarding his 'round bodies' as parasitic organisms, and adopted the new name of 'dyskeratosis follicularis' as the most appropriate description of the histological changes which are so characteristic of the disease. It is now universally agreed that the 'round bodies' are degenerated epithelial cells.

Incidence

The disease is met with in every country and up to 1936 some 400 cases have been described. It is not contagious; in about half the reported cases a familial or hereditary history has been recorded with a slight preponderance in the male sex. In contrast with previous observations later experience shows that the disease is commoner before than after puberty—about half the recorded cases having been noted under the age of 10, and its commencement after 30 is rare.

Associated symptoms

Mental backwardness and sexual frigidity are occasional concomitant symptoms, and Darier suggested that endocrine deficiency may play a part in causation—the thymus, thyroid, and sexual glands being the most probable seats of disturbance.

Histology

In the great majority of instances the pilo-sebaceous opening is seen to be plugged with horny cells, sometimes with definite hornlike projections. The rete is moderately thickened, the inter-papillary processes elongated, but without marked papillomatous proliferation. The '*corps ronds*' of Darier are found between the prickly cells, both in the neighbourhood of the pilo-sebaceous orifice and about the orifice itself. They are larger, sometimes much larger, than the normal cells and form very conspicuous objects, with their characteristic glistening double-contoured envelope (see Fig. 68).

3.—CLINICAL PICTURE

Distribution on the body

The eruption is usually observed first about the head and face, spreading later to the limbs, the chest, and genital regions. The crusted papules already described are certainly predominantly, but not exclusively, follicular in position. They may assume a dirty brown or, as in

one of my own cases, a bright yellow colour simulating favus. A symptom which is so frequent as to be of help in diagnosis is the occurrence of lesions, clinically indistinguishable from flat warts, on the palms and soles and the backs of the hands; the typical 'round bodies' have been demonstrated in these lesions. In regions of the body where moisture is common, as in the armpits and groins, tumour-like vegetations may form, often accompanied by an offensive discharge. Darier has noted the similarity to seborrhoea in the distribution of the earlier lesions on the temples and naso-labial furrows, the scalp, the conchae of the ears, the inter-mammary and inter-scapular regions, and the flexural folds, as also in the presence of a general greasiness of the skin. It is, however, noteworthy that although the scalp may be heavily affected, as in a case reported by me in 1916, the hair is not lost. The mucous membranes are rarely involved, but lesions in the mouth, the vulva, pharynx, and oesophagus, and a hypertrophy of the papillae of the tongue, have been recorded. The nails may be furrowed and brittle. There may be patches of more or less deep pigmentation of the skin apart from the papular eruption.

Subjective symptoms are almost entirely absent. Itching is usually negligible in degree but serious discomfort may result from the offensive smell when papillomatous masses form. It is remarkable that with so chronic an affection of the epithelium malignancy has been reported in only one case (Wende, 1908).

4.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

In a well-established case the clinical features may be so typical as to allow of identification without biopsy, but the final diagnosis of Darier's disease must depend upon finding the characteristic 'round bodies'; where these are absent diagnosis must remain uncertain.

There is a group of cases reported as 'keratosis follicularis contagiosa of Brooke', the nature of which is much disputed. Brooke (1892) described and pictured such cases and reported a series of six children in one family, three in another, with some isolated cases. I recorded three cases in 1901, two sisters and a brother, which were regarded by Brooke as examples corresponding to his description. Brooke's argument for differentiating his own familial cases from Darier's disease rested upon (i) their apparent spread by contact, (ii) their improvement with anti-parasitic treatment, and (iii) the absence of the round bodies in the lesions which were examined by Brooke, by Wickham, and by Unna, with a negative result.

*Diagnosis
from
keratosis
follicularis
contagiosa
of Brooke*

In a case reported by Elliott under the title of 'keratosis follicularis contagiosa of Brooke' the clinical description resembles Brooke's but there was no familial history. This group remains so rare and so ill-defined that no very positive statements can be made about it.

It is unfortunate that the term 'keratosis follicularis' has been some-

*From lichen
spinulosus*

times applied to another affection, lichen spinulosus, which has some resemblance to Darier's disease, in that the typical lesion is a 'follicular papule', and it is commoner in children than in adults. But the distribution is different, the extensor rather than flexor surfaces being affected, the lesions are much more scanty, tend to be grouped, and to appear in consecutive crops; they are amenable to treatment or disappear spontaneously, and there are no '*corps ronds*' in the section.

*From
acanthosis
nigricans*

The discoloration of the skin and the concomitant eruption of multiple warty lesions obviously afford some possibility of confusing Darier's disease with acanthosis nigricans, an even rarer affection in which these two symptoms predominate. The histology, however, is entirely different; in acanthosis there is a diffuse papillomatosis and there are no round bodies. The usual termination in visceral carcinoma constitutes a striking contrast to the benign behaviour of Darier's disease (see ACANTHOSIS NIGRICANS, Vol. I, p. 75).

5.—TREATMENT

Some mitigation of the subjective discomfort may be obtained by local applications, such as emolient baths and ointments, but the affection is essentially incurable, and once established commonly persists throughout life.

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DAUER NARCOSI

See NARCOSIS, PROLONGED

DAY BLINDNESS

See BLINDNESS, Vol. II, p. 411; *and*
VISION, SYMPTOMATIC DISTURBANCES

DEAF-MUTISM

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Reference may also be made to the following titles:

CRANIAL NERVE	EAR DISEASES
AFFECTIONS	HEREDITY AND
CRETINISM	CONSTITUTION
DEAFNESS	

1.-DEFINITION AND AETIOLOGY

283.] 'Deaf-mutism describes that amount of deafness which, occurring in childhood, involves dumbness' (J. Kerr Love). By this definition it is clear that the deaf-mute is dumb because he has never heard words and has therefore never learned to use words, not because he has a fundamental incapacity to perform the act of speaking. Unless the deafness is accompanied by mental defect the dumbness is a result solely of the deafness; this must never be forgotten when considering the treatment of a deaf-mute.

Heredity

Heredity is a factor which is not yet fully understood. There is evidence that true congenital deafness is certainly hereditary, and that

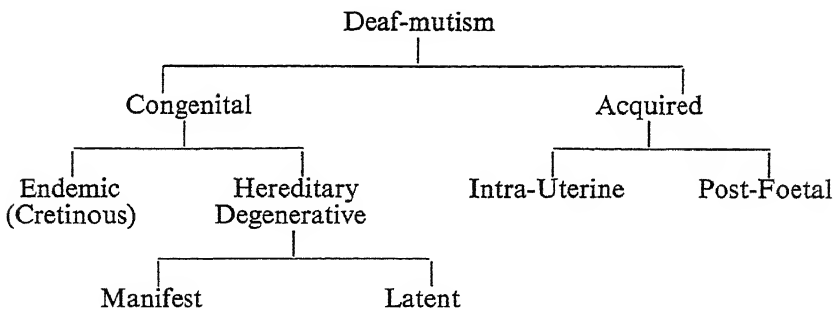
in most of the family trees examined the deafness is a Mendelian recessive. On the other hand there is no real proof that acquired deafness leading to mutism is in any way hereditary other than by the transmission of a common infection such as syphilis.

Mutism may be due either to deafness present at birth or to deafness acquired before the child can learn to speak. Clinically this is an important distinction, for it is possible that in the second case some subconscious memory of sound (if such a term be permissible) may remain, and such an impression is of the utmost value to the teacher. It is no exaggeration for Kerr Love to say that the acquisition of speech by the blind deaf-mute, Helen Keller, was 'the greatest individual achievement in the history of education'; for the first two years of her life, however, she could see and hear and, although she cannot now recollect either sound or colour impressions, the receipt of those impressions may have been a factor in her success. From a strictly scientific point of view a further distinction must be made among the deaf-born—between those whose deafness is due to inborn developmental defect, and those whose deafness is due to intra-uterine infections, such as syphilis.

The best working classification of deaf-mutism is that of J. S. Fraser, which is based on the work of Hammerschlag and Urbantschitsch.

Aetiology

*Classification
of
deaf-mutism*



2.—TRUE CONGENITAL DEAF-MUTISM

(1)—Endemic Cretinous

The endemic cretinous cases (Siebenmann's type) are usually feeble-minded and often goitrous from birth. Goitre is often present in other members of the family. Occasionally, but rarely, the deafness is the only symptom of cretinoid degeneration. It is said that only 25 per cent of cretins have normal hearing.

(2)—Hereditary Degenerative

Hereditary degenerative deafness may be latent or manifest. Those in whom it is latent, although showing no evidence of deafness, can transmit the tendency to this condition. The manifest cases are classified

thus: (1) Total defect of both labyrinths (Michel's type)—this is very rare. (2) Defects of the bony and the membranous labyrinth (Monodi's type)—this also is rare. (3) Defects of membranous labyrinth in the cochlear and vestibular parts—this is frequently associated with retinitis pigmentosa. (4) Sacculo-cochlear degeneration (Scheibe's type)—this is the most common variety. The utricle and canals are intact, and the vestibular reactions to rotation and the caloric tests are therefore normal. This distinguishes the condition from the first three groups. A further, and most important, distinction is that in these cases there are usually remnants of hearing to certain tones (the so-called 'islets' of hearing).

3.—ACQUIRED DEAF-MUTISM

(1)—Intra-Uterine

Causes

This comprises cases of intra-uterine meningitis and congenital syphilis. There is considerable difference of opinion as to the importance of syphilis as a causative factor. On the whole it does not seem to be a frequent cause (seven cases in Fraser's series of one hundred and forty deaf-mutes).

(2)—Post-Foetal

Trauma

Cases occur in which the deafness is due to fracture of the base of the skull. Deafness from this cause is rare, as such a severe injury is usually fatal in young children.

Infection

The immediate cause of deaf-mutism due to infection is a neuro-labyrinthitis. Labyrinthitis may be secondary to middle-ear suppuration, either acute or chronic, with invasion of the labyrinth through the windows or by erosion of bone; or it may be caused by meningitis, with invasion of the labyrinth through the internal auditory meatus without any disease of the middle ear. Scarlet fever and measles may cause labyrinthitis by either route; syphilis and mumps probably by meningitis.

4.—MORBID CHANGES

The condition of the brain and the auditory tracts in deaf-mutism has not been fully worked out. In many of the cases examined there have been abnormalities in the cortex or the tracts, but these may, to some extent at any rate, be due to lack of development of the peripheral organ. The statement of Castex that the majority of cases of deaf-mutism are due to defects in the temporal cortex is not generally accepted. It is probable that there is a small group of cases of congenital aphasia in children not otherwise mentally deficient, but these children are not, strictly speaking, 'deaf' mutes. It is also true that in many cases of true congenital deafness histological examination has shown traces of otosclerosis.

5.-TREATMENT

In true congenital deaf-mutism the only possible prophylaxis is to discourage the marriage of deaf-mutes. Much acquired deaf-mutism could be prevented by treatment of the inflammatory condition as early and as thoroughly as possible. *Prophylaxis*

The deaf-mute child must be regarded not as a deaf-and-dumb object of pity and charity, but as a normal, often indeed exceptionally intelligent, person who is, unfortunately, deaf. This applies to the great majority of deaf-mutes. *Treatment*

The methods of training are the manual and the oral. The object of the manual method is to teach the child to communicate by means of signs; the object of the oral method is to teach him to speak and, by lip-reading, to understand the speech of others. The advantages of the oral method are immeasurable; the deaf-mute orally taught is not shut off from the everyday speaking world; he is not dependent on the help of the few normal people who have mastered a sign-language; any traces of hearing he has can be developed, and as a result his mental development advances. Helen Keller said that when she learned to speak she 'thought three times as quickly'. On the other hand it is no use trying to teach a mentally defective deaf-mute orally; the manual method is the most that he will be able to master. *Training*

Teaching these children to speak requires an elaborate technique that can only be learned by special training, and therefore the actual teaching must be done by experts. The question always arises whether deaf children are better at home or in an institute. Mentally defective deaf-mutes should certainly be trained and, if possible, kept in an institute; they will not be able to look after themselves or to earn their own living. For the intelligent deaf-mute the answer depends on the circumstances. If the parents are intelligent and helpful and if a skilled teacher is available, it is far better that the deaf-mute child should live in normal surroundings, not in a little world of deaf-mutism. But a word of warning is needed; the deaf-mute is often an engaging and intelligent person who is the pet of a large family. In this case he, or still more she, is apt to get everything done without the trouble of talking.

The most recent method of training is that advocated by Philip Franklin, who believes that 84 per cent of deaf-mutes should be able to hear speech amplified by a hearing aid. He uses an audio-amplifier, which increases the loudness of sounds derived from a series of gramophone records to any required degree. These records are graduated from noises to alphabet sounds and so on to words and sentences. With the audio-amplifier he uses a 'teletactor'. This conveys the amplified sounds to a vibrating plate, on which the child's fingers are placed. Thus when the child sees the teacher's lips form the sound he simultaneously feels it by his fingers on the teletactor plate and, in some cases, hears it from the amplifier. *Use of audio-amplifier and teletactor*

It is generally agreed that training should start as soon as possible, for choice at 2 to 3 years of age; the earlier training is started the better is the child's voice.

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DEAFNESS

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Reference may also be made to the following titles:

CRANIAL NERVE
AFFECTIONS

DEAF-MUTISM
EAR DISEASES

1.—DEFINITION

284.] Deafness may be defined as the consequence of some defect in hearing which makes it difficult for the patient to appreciate sounds or combinations of sounds as readily as a normal person.

Perfect hearing depends on the integrity of the hearing mechanism of the ear and of the auditory tracts and centres. At present our knowledge of the tracts and centres is so inexact and the available clinical evidence is so scanty that, in a brief summary such as this, it is proper to consider only the peripheral apparatus, that is, the ear itself and the auditory nerve.

2.—ANATOMY OF THE EAR

The hearing mechanism of the ear consists of two parts, the conducting and the receiving. The conducting apparatus, which includes the outer

*Mechanism
of hearing*

ear, tympanic membrane and middle ear, with the ossicles (malleus, incus, and stapes), and the attached intra-tympanic muscles, is responsible for the collection and transmission of sounds to the receiving apparatus. This apparatus, the cochlea, consists of the nerve-endings of the auditory nerve arranged along a vibrating membrane, which is slung in a double, coiled tube; both the inner and outer tubes are filled with fluid.

It is generally believed that sounds enter the ear, and, by air-waves, set the membrane and ossicles vibrating; that the ossicles convey the vibrations to the oval window and so set the fluids of the cochlea vibrating, and that the wave of vibration in the fluids stimulates the hair-cells of the nerve-endings. It is generally agreed that sounds may also be conducted through the bone of the skull direct to the cochlear fluids ("bone conduction").

*Function of
parts of the
ear*

All sorts of important duties have been attributed to the tympanic membrane and the ossicles, but our real knowledge can be summarized thus: (1) In man the auricle of the ear is of no importance to hearing. (2) The importance of the tympanic membrane has been greatly exaggerated; many people hear excellently with perforated membranes, scarred membranes, or no membranes at all. (3) The ossicles are important, but the outer two, the malleus and incus, are not absolutely essential; many people hear quite well without them. (4) On the other hand it is absolutely essential that: (*a*) the cochlear fluids should be capable of movement, and (*b*) that they should be at an optimum tension. These conditions are fulfilled only when the stapes is normally movable in the oval window. (5) It is also essential that the nerve-endings in the cochlea and their fibres are intact.

3.—TYPES OF DEAFNESS

*Need of early
investigation*

For practical purposes the important sounds are those of speech; it makes little material difference to our welfare if we cannot hear the low drone of a far-off aeroplane at one end of the range of audible sounds or the high squeak of a bat at the other. But if the deafness either for high or low notes increases, the essential hearing, the power of appreciating the spoken word, rapidly fails. For this reason it is vitally important that every case of deafness, however slight, should be thoroughly investigated at the earliest possible opportunity. Too often the patient waits until he has real difficulty in hearing ordinary conversation before he regards the condition seriously. If, as is often the case, only some slight, permanent, and apparently stationary loss of hearing is found, he can be reassured, but he should always be warned to report immediately any increase in deafness, however slight; in many cases it is well to make a routine examination at regular intervals.

It is important to realize that many patients are unwilling to admit,

even to themselves, that their hearing is defective, and that parents are apt to regard the deafness of their children as inattention. In this belief there is just enough truth to be dangerous. With any degree of deafness sufficient to make ready understanding of speech difficult, 'hearing' becomes 'listening'; the deaf patient has to make a conscious effort to understand conversation, and this needs constant attention, just as listening to a foreign language, however well one may understand it, requires attention. Continual attention entails a certain strain, and the result of strain is fatigue. It is common knowledge that strain causes fatigue more readily, or in common parlance that 'we feel the strain more', when the general state is poor, and this is most noticeable in deaf patients; many patients who hear ordinary conversation with ease when they start the day's work, find themselves at night too deaf to enjoy a theatre or a dinner party.

The character, intelligence, and degree of education of the patient are of great importance in dealing with any case of deafness. In most cases there is a considerable surviving amount of useful hearing, and Yates draws a distinction between 'compensated' deafness, in which this residual hearing is utilized to the utmost by the patient, and 'uncompensated' deafness. It largely depends on the patient to what extent he can 'compensate' his deafness. The shy and reserved patient who is timid about making mistakes in conversation is very apt to give in, neglect what hearing he has, and withdraw more and more into himself. The less intelligent patient is not quick enough to guess the meaning of partly heard words or sentences. The uneducated patient has too small a vocabulary to supply any partly heard word with which he is not perfectly familiar. Thus a rather stupid labourer is made nearly completely deaf by a comparatively small defect of hearing.

There are three kinds of difficulty in hearing, all of which merge into one another. (1) Some sounds may be completely lost, so that however loudly they are spoken parts of words made up of those sounds cannot be heard. (2) Some sounds can only be heard if they are very loud; thus parts of an ordinary conversation are missed by the patient. (3) The patient hears, but he 'hears slowly'; the interpretation of the sounds seems to take abnormally long. Many deaf people hear quite well if words are spoken slowly, whereas ordinary conversation seems a meaningless jumble. This may possibly be due to some mechanical defect in the hearing apparatus, but it is quite probable that the patient has no time for 'subconscious guessing', or else the strain of listening is making itself felt. This 'time lag' may be observed by people with normal hearing listening to an indistinct speaker; we ask him to repeat some sentence which we did not catch, and after he has said a few words we know what the whole sentence meant. It is most encouraging to the slightly deaf patient to realize that even the best of hearing is not adequate against the mumbling, the indistinct, and the slipshod speaker.

Hearing and listening

'Compensated' and 'uncompensated' deafness

Classification of difficulties in hearing

4.—DIAGNOSIS

Accurate diagnosis is as important in the treatment of deafness as in the treatment of any other complaint. It must at once be admitted that our diagnosis of the various kinds of deafness is still largely empirical, but this only makes it the more important to make our diagnosis as precise as is possible. Diagnosis would be much simpler if we forswore such pseudo-scientific apologies for ignorance as 'thickened drums', 'dry catarrh', and the like.

*Classification
of types of
deafness*

It is usual to classify deafness as middle-ear deafness, nerve deafness, and otosclerosis. Mixed deafness is the condition in which both the middle ear and the nerve are affected. Otosclerosis is a mixed deafness, but is classed by itself as it is characterized by definite pathological changes.

(1)—Middle-Ear Deafness

Middle-ear deafness is the condition in which the normal passage of air-borne sounds to the cochlea is disturbed. It is well described as obstructive deafness.

*Causes of
middle-ear
deafness*

The patients have difficulty in hearing because the movement of the ossicles is hindered; this interferes with the mobility of the oval window, and so with the movement of the cochlear fluids. The most common cause is a mass of wax in the external auditory meatus, which slips deeply in and presses on the tympanic membrane. The impressed membrane drives in the ossicles and fixes the stapes in the oval window. The same result is achieved, but in a different way, by an effusion of catarrhal or purulent fluid into the middle ear. Then the membrane is bulged outwards and fixed, and, as the malleus is inserted into the drum and the incus and the stapes are bound together and the incus bound to the malleus, again the stapes is immobilized. If the Eustachian tube is obstructed air cannot enter the middle ear; the air that is already there is absorbed; the atmospheric pressure in the external auditory meatus pushes in the tympanic membrane and with it the ossicles, and again the oval window is immobilized. If any of these conditions are left unremedied the intratympanic muscles, which support the ossicles, may be over-stretched or undergo fibrosis; and in the inflammatory conditions the mucous membrane around the oval window may also become fibrosed.

In persistent suppuration of the middle ear, first of all there is some destruction of the tympanic membrane; this is comparatively unimportant. Next, there may be necrosis of the ossicles; this is more important but is not necessarily fatal to hearing unless the process invades the cochlea. Lastly, there may be fibrosis and scarring of the mucosa over the inner wall of the middle ear with some limitation of movement of the stapes; this may destroy all useful hearing in the affected ear. Middle-ear deafness may occur at any time of life.

The peculiar features of middle-ear deafness are: (1) The high tones are heard better than the low. (2) A tuning-fork of medium pitch is heard better on the bone of the mastoid than at the orifice of the meatus; this is known as the negative Rinne sign and shows that conduction by bone is better than by air. (3) A tuning-fork placed on the mid-line of the skull is heard better in the deaf ear; this is Weber's test. (4) Bone conduction is apparently lengthened in comparison with the normal ear; this is not really the case, for, if the observer closes his own meatus and compares his bone conduction with that of the patient, whose meatus also is closed in the same way ('absolute bone conduction'), there is no difference. (5) In middle-ear deafness there are usually obvious changes in the appearance of the tympanic membrane. It may be reddened and bulged with pus (acute otitis media); pale and bulged with clear fluid, perhaps with bubbles, or a shifting fluid level (catarrhal otitis media); there may be a perforation, either dry or emitting pus; or the whole tympanic membrane, or part of it, may be pressed against the inner wall of the middle ear. (This last appearance is the one usually seen in Eustachian obstruction.) (6) In middle-ear deafness there is often evidence of recent chronic or acute inflammatory conditions in the nose or nasopharynx.

*Clinical signs**Negative Rinne sign**Weber's test**Bone conduction**Tympanic membrane*

(2)—Nerve Deafness

Nerve deafness is due to changes in the cochlea or in the nerve trunk. Apart from gross mechanical injury, such as fracture of the basis cranii, the only important lesions of the nerve trunk are tumours of the nerve or of the cerebello-pontine angle, syphilitic neuro-meningitis and, very rarely, gumma. Lesions of the cochlea may be classified as: (1) traumatic; (2) infective; (3) toxic; (4) degenerative; (5) caused by intracranial conditions; and (6) haemorrhagic.

*Causes**Lesions of cochlea*

Lesions due to injury

The following injuries may cause lesions: concussions of the labyrinth by blows on the ear or side of the head or by explosions, fractures of the basis cranii, or loud and continuous noises (e.g. boiler-makers' deafness, weavers' deafness, and gun deafness).

Infective lesions

Infective lesions may result from the following conditions: (a) Suppuration of the middle ear; labyrinthitis either serous or purulent. Serous labyrinthitis does not always permanently destroy the hearing but purulent labyrinthitis always does. (b) Syphilis, especially congenital syphilis. Acquired syphilis seems to attack the nerve trunk more often than the nerve-endings. (c) Mumps and epidemic cerebrospinal fever. In these conditions the invasion is probably from within the cerebrospinal spaces into the inner ear along the lymph tracts of the auditory nerve.

Toxic lesions

Exogenous causes are quinine, tobacco, and perhaps arsenic and bismuth. Endogenous causes are septic foci, especially in dental tissues.

Degenerative lesions

Especially vascular and senile.

Intracranial lesions

Intracranial causes of inner-ear deafness (apart from meningitis) are not fully understood. It is probable that intracranial tumours cause deafness principally by a rise in intracranial pressure which prevents the normal escape of the cochlear fluids into the cranial cavity and so produces a 'choked cochlea'.

Haemorrhage

Haemorrhage is very rare, and is nearly always due to leukaemia.

It is interesting to note the close resemblance between conditions affecting the auditory nerve and those affecting the optic nerve. Nerve deafness usually occurs in middle or late life.

Clinical signs Nerve deafness, which is also known as inner-ear deafness or perception deafness, has various characteristic features. (1) High notes are lost earlier than low. (2) Tuning forks are heard better by air than by bone conduction, but are not heard by either as well as in a normal subject; this is the shortened positive Rinne sign. (3) A tuning fork placed in the mid-line of the skull is heard better in the better ear. (4) Bone conduction is really shorter than in the normal ear. (5) There are no characteristic changes in the tympanic membrane.

Shortened positive Rinne sign
Bone conduction

(3)—Otosclerosis

Aetiology Otosclerosis is a degenerative condition of the whole middle and inner ear, including the nerve-endings and fibres, and is associated with changes in the bone of the inner wall of the middle ear and of the cochlea. (The classical description is that the stapes is fixed in the oval window by bony ankylosis, but this is not a constant feature.)

As a rule the condition starts in adolescence or early adult life. It is more common in women than in men; it is made worse by pregnancy or by any other severe strain, mental or physical, and is made very much worse by any intercurrent aural inflammation.

Clinical signs The characteristic features of otosclerosis show the 'double attack' of the disease on the middle and inner ear. (1) There is a loss of extreme high and low notes; this defect encroaches continually on the hearing from both ends of the scale. (2) Tuning forks are heard much better by bone than by air. (3) A tuning fork placed in the mid-line of the skull is heard better in the worse ear. But (4) although the air conduction is more seriously affected than bone conduction, sooner or later in any case there is always some loss of bone conduction in comparison with a normal ear. (5) In some cases the promontory of the inner wall of the middle ear is congested, and shows through the membrane as a pink

Bone conduction

'Flamingo pink' sign

flush; this is the 'flamingo pink' sign of the classical descriptions. Otherwise, apart from occasional abnormal translucency, the membrane does not show any characteristic changes. (6) Many patients with otosclerosis appear to hear better in a noise: this phenomenon is the 'paracusis of Willis'. (7) In most cases tinnitus is present at some stage of the disease. (8) In many cases there is a definite familial history of deafness. (9) The disease is generally bilateral, but in a small minority of cases it is limited to one ear. In these cases the brunt of the attack is borne by the cochlea, and there is a nearly complete nerve deafness. This variety is known as Manassé's otosclerosis.

*Paracusis
of Willis*

*Manassé's
otosclerosis*

5.—TREATMENT

It is a useful general rule that we should never say that nothing can be done to assist a deaf person. We often have to say that no treatment is of any use, but that should not end the matter. Even in the rare cases in which the patient is completely deaf he can be encouraged to learn lip-reading. If there is some surviving hearing, as there usually is, it can often be improved by a 'hearing aid', and in some cases in which there is useful, but very defective, hearing a great deal can be done by the patient himself.

A second rule is that, so long as treatment gives real improvement we should resolutely persevere with that treatment until the maximum improvement which can be reached is maintained at a stationary level.

The third rule is that we should never persist in treatment which does not give definite improvement; such a course of action may do harm physically and will certainly do so mentally, for depression follows failure and depression is a deadly enemy of the deaf. These general rules apply to all cases of deafness. The treatment of the individual case must be dictated by the diagnosis.

In middle-ear deafness the aims of treatment are to restore the normal function of the middle ear, to avoid fibrotic changes in the inner wall which might impede the mobility of the oval window, and to guard against relapses. The line of treatment differs in suppurative and in non-suppurative conditions.

*Treatment of
middle-ear
deafness*

In the suppurative conditions the treatment of deafness, although it must not be forgotten, is subordinated to the safety of the patient. Our first duty is to save the patient's life; his hearing is a secondary consideration.

*Suppurative
conditions*

In the acute conditions (acute otitis media and acute mastoiditis) there is usually no antagonism between our two objects. The earlier a bulging membrane is incised the better for the patient's safety and the better for his hearing. If the mastoid is definitely infected it should be freely opened and drained, and both the patient's health and his hearing will be the better for it. From the point of view of hearing alone, apart from the danger to life, when an ear has been dis-

Acute

several weeks and it is certain that the discharge comes from the mastoid and not from the nasopharynx via the Eustachian tube, the wisest course is to eliminate the focus of infection in the mastoid.

Chronic

In chronic conditions, in which the mastoid antrum, or the attic, or both are infected, it is not always so easy to eliminate the disease without considerable risk to the hearing. The patient's safety must come first, but, subject to this, there are many modifications of the complete or radical operation which will often cure the suppuration without any further damage to the hearing. As far as possible the radical operation, which converts the middle ear, mastoid, and meatus into a single cavity and demands the removal of the malleus, incus, and remains of the drum, should be reserved for cases in which the hearing is almost entirely lost. If it has to be performed when there is still useful hearing the greatest care should be taken to avoid damaging the mucous membrane covering the inner tympanic wall. In some cases good hearing is retained after the radical operation, but the surgeon can never promise this.

In one group of chronic suppurations operation should never be performed. These are the cases in which the discharge does not come down from the mastoid but comes up from the nasopharynx through the Eustachian tube. Here a mastoid operation is perfectly useless and palliative treatment must be relied upon.

Prevention of relapses

In acute and chronic cases, when the ear has been dealt with, it is necessary to guard against relapses by the elimination of any source of sepsis in the nose (accessory sinusitis), nasopharynx, or mouth (septic tonsils, adenoids, or infected teeth).

After-treatment

When the discharge has ceased and any severe degree of permanent deafness remains it should be treated on the lines laid down later (see 'permanent deafness', p. 563). In some cases a small piece of cotton-wool soaked in oil or soft paraffin and applied to the perforation or to the inner tympanic wall (the so-called artificial drum) gives considerable help.

Non-suppurative conditions

Middle-ear deafness, not due to suppuration or to mechanical obstruction by wax, is usually the result of obstruction of the Eustachian tube by swelling, with, or more frequently without, catarrhal exudate in the middle ear.

The first step is to relieve the tubal obstruction and remove any fluid in the tube or middle ear. As a rule this can be done immediately by Eustachian catheterization, with aspiration of the fluid, if any, and inflation of the middle ear. In a very few cases it may be necessary to incise the membrane to let fluid escape. Treatment of the Eustachian tube should be continued until the tube is clear, and any source of nasopharyngeal irritation should be dealt with. It is important, however, that the indications should be precise; a fear of relapse must not be allowed to lead to haphazard surgery, especially not to operative ~~and~~ ^{measures} of uncertain value or of a severity disproportionate to the middle ear ~~of the condition~~. It may be laid down that in true middle-

'Flamingo pink' sign

ear deafness, once the patency of the tube has been restored no nasopharyngeal surgery is likely further to improve the hearing: it is only of value as guarding against recurrence of tubal infection.

In nerve deafness the only hope of real improvement lies in finding a curable cause. If this can be done, as in some syphilitic and many toxic cases, recovery may be dramatic. But here again goodwill must not bias our judgement; for example, there is little hope of helping an elderly patient with advanced nerve deafness and long-standing ethmoiditis by an extensive operation on his sinuses; in fact the shock of operation may actually make his hearing worse.

Otosclerosis must, at present, be regarded as permanent deafness. Occasionally patients seem to have been helped by various kinds of endocrine treatment or by phosphorus or arsenic. In 1935 A. A. Gray reported good results from the intra-tympanic injection of thyroxine. Unfortunately further work has shown that this optimism was unfounded. The method has not borne the test of rigorously controlled observation and later results have been disappointing. Plastic operations have been designed to make artificial windows in the cochlea and so replace the occluded oval window. Unfortunately these operations are technically very difficult and usually give only temporary improvement.

Permanent deafness is a useful but inaccurate term for the residual deafness which defies specific treatment, such as middle-ear deafness persisting after the patency of the Eustachian tube has been restored. Probably most of these cases are really spontaneously arrested, or very slowly progressive, otosclerosis. It is convenient to describe them as permanent, but the actual degree of deafness in any case usually fluctuates to some extent with the patient's general condition. Many methods have been tried without much success. Although the Zundt-Berguet Electrophonoïde for stimulating the ear by graduated sounds has been extensively used for the last twenty years, only a small minority of workers have reported good results; the general opinion is entirely unfavourable. Diathermy has been tried, but on the whole without much success. The most important points in treatment are maintenance of the patient's health at the highest level; avoidance of cold and fatigue; avoidance of aural overstrain as far as possible, with deliberate rest of hearing by insisting that the patient spends some time every day in complete silence if need be, and strict moderation in the use of tobacco and other possible deleterious agents. Particular attention should be paid to the vascular condition, and it should be noted that too low a blood-pressure, as well as one too high, is deleterious for these patients. Lip-reading gives moral support, quite apart from its actual utility, and many patients are greatly helped by a prescribed hearing aid.

Hearing aids are either: (1) The non-electrical, and 'speaking tubes'. They do not magnify the sound, but preserve a natural tone and there is no trouble in using them. Unfortunately they are very conspicuous.

*Nerve
deafness*

Otosclerosis

*Permanent
deafness*

HOMICIDAL

LEGAL

EM

ATIONS,

LEGAL

are the usual commercial type. They are useful for deafness of the middle tones, but they are not much help in senile and nerve deafness where the upper tones are affected. (3) Valve-amplifiers. These are the most adaptable and are specially useful for high-tone loss, but they are bulky and expensive. A hearing aid should never be chosen at random, and should never be bought without a period of trial in the patient's home.

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DEATH, SUDDEN AND UNEXPECTED

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Reference may also be made to the following titles:

ANEURYSM	CONCUSSION AND COMPRESSION
ANGINA PECTORIS	CORONERS AND INQUESTS
AND CORONARY	EPILEPSY
THROMBOSIS	HEART
APOPLEXY	LYMPHATISM
ASPHYXIA	POISONING, HOMICIDAL
BRAIN ABSCESS	AND SUICIDAL
BRAIN TUMOUR	POST-MORTEM
COMA	EXAMINATIONS,
	MEDICO-LEGAL

285.] For medico-legal purposes this article includes all instances of persons found dead or dying from causes unknown, and deaths following brief or obscure illnesses, as well as deaths which are observed to be sudden. These cannot be certified until a post-mortem examination has been made on the authority of the coroner, to whom all such deaths must be reported.

*Necessity
for inquest*

If the death is found to be due entirely to natural causes, the coroner issues the death certificate without holding an inquest. When the necropsy reveals an unnatural cause of death—e.g. injury or poison, or an unnatural complication of a natural disease—e.g. accidental suffocation during an epileptic fit, an inquest is held. If the necropsy does not show any cause of death, it may be because the cause has been overlooked or because it is due to a poison which does not leave a clear indication in the body, e.g. narcotic; in such cases the inquest must be supplemented by a chemical analysis to enable the diagnosis of poison to be proved or excluded. In my experience about 10 per cent of sudden deaths in which at the time no unnatural cause was suspected necessitate the holding of an inquest. (See also article CORONERS AND INQUESTS, p. 437.)

Sudden deaths which are not unexpected can be certified by the medical attendant when he knows by previous examination that the patient had a disease, e.g. aortic incompetence, which is liable to cause sudden death, provided that he has seen the patient within a reasonable time of death (the registrar refers such cases to the coroner if he considers the interval too long), and provided that the circumstances of the death do not rouse suspicion that an unnatural condition may have supervened.

Some causes of sudden death, such as rupture of an aortic aneurysm, or a cerebral haemorrhage, are found without difficulty, but it is essential in these cases to perform the post-mortem examination so as to be able to present a complete pathological picture of the disease and to exclude violence or other unnatural condition as an accelerating cause.

In many cases of sudden death, no medical history of any value can be obtained; unless therefore the examiner is thoroughly trained in post-mortem technique and has had considerable pathological experience, he may easily fail to find the cause, or to realize that it is the cause, particularly if the lesion is small or if it is situated in a part which he does not usually examine. A systematic and thorough examination is essential in all cases.

It sometimes happens that death is due to the combined action of two or more lesions or diseases, no one of which alone would appear to be sufficient to cause death; this is not uncommon in old persons. Subsequent microscopical or bacteriological examination may reveal the cause of death in an otherwise puzzling case.

1.—COMMON CAUSES OF SUDDEN DEATH

In the following account of the causes of sudden death, attention will be directed particularly to the more obscure and difficult causes and their interpretation, and to the methods which should be used in order to discover them.

Wherever in the body the fatal disease has its origin, death is due to involvement of one of the three master systems of the body, the circulatory, the respiratory, or the nervous system, either alone or in combination. Thus a small haemorrhage in the pons may paralyse the chief respiratory centres and lead to death from asphyxia. It is to these systems therefore that attention should be particularly directed in the investigation of the cause of death. *Causes of death*

(1)—Diseases of the Circulatory System

The circulatory system is much the most frequent site of the fatal lesion in sudden death.

(a) *Disease of the Coronary Arteries*

Disease which interferes seriously with the circulation through the coronary arteries of the heart is the most frequent lesion, and accounts for about 25 per cent of all cases of sudden death from natural causes. These arteries must therefore be opened up thoroughly from their orifices along the trunks and main branches.

The two arteries come forward and turn right and left along the auriculo-ventricular sulcus. Each artery divides into two main branches, a descending branch which passes downwards, the left along the anterior interventricular sulcus, the right down the right margin of the heart, and a transverse branch which continues in the course of the main vessel, the terminal portion of the right artery passing downwards in the posterior interventricular sulcus. The division of the right artery occurs at a point several inches from its origin, the left divides close to its origin, and occasionally the two branches arise from the aorta as separate vessels. *Anatomical distribution of coronary arteries*

The arteries are opened most easily with a small pair of scissors, one end of which is probe-pointed, and the cuts should be carried as far as the vessels can be opened easily. When the artery is much narrowed by disease this method is supplemented by transverse cuts with a knife, the cuts being made close together to avoid the risk of missing a tiny thrombus. When the vessel is much calcified this method also is difficult, and it may be necessary to remove the calcified portion and to decalcify it for a few hours in, for example, 10 per cent sulphurous acid, in order to determine whether the narrowing is complicated by thrombosis. The disease is generally atherosclerosis with a well-marked tendency to calcification. The left artery is generally the more diseased, and *Technique of opening coronary arteries*

especially the descending branch or a large branch given off from the left side of that branch.

Slowly progressive narrowing of the arteries may give rise to typical anginal attacks prior to the fatal seizure, but the attacks are often atypical and may be attributed to indigestion, gall-stones, or other abdominal disease.

Fibrosis of heart muscle

Fibrosis of the heart muscle, almost invariably in the wall of the left ventricle, develops frequently in the course of the disease. The areas of fibrosis may be single or multiple, they may be visible on the inner surface of the ventricle or in the papillary muscle: the ventricle should be searched for them by close parallel cuts through its whole thickness and extent.

Age incidence

The fatal attack occurs generally in middle or old age, but it may be earlier, and occasionally accounts for death between the ages of 20 and 30. It is in younger subjects that syphilitic disease of the artery is more likely to be found.

Coronary thrombosis

Coronary thrombosis occurs almost invariably in areas already narrowed to some extent by disease; the thrombi generally occlude completely the narrow portion; they may be small and in very narrow areas no larger than a pin's head. Thrombi are adherent to the vessel wall and cannot easily be detached intact. An old thrombus of a brownish-yellow colour is occasionally found, generally in the right artery. In many cases of coronary thrombosis there is no history of previous attacks, the artery not having been sufficiently narrowed before thrombus formation to interfere seriously with the circulation through it. Death may follow immediately after the formation of a thrombus, but in some cases the acute symptoms tend to subside, and death then occurs suddenly a few hours or several days later.

Morbid changes in heart

In these cases there is found infarction of the heart wall, with progressive softening, in the area supplied by the thrombosed vessel, the later deaths being generally due to rupture of the heart through the softened area; this condition is the commonest cause of rupture of the heart. Occasionally one of the papillary muscles undergoes infarction; rupture of the muscle may cause sudden death from acute mitral regurgitation.

Sequelae

Thrombosis on the inner surface of the left ventricle over an area of infarction occasionally leads to sudden death from cerebral embolism. Occasionally acute pericarditis develops on the surface of a cardiac infarct and may involve the whole of the pericardial cavity. I have seen one case in which fibrinous exudate obliterating the pericardial cavity prevented the heart from rupturing through a very soft infarct, the patient dying from damage to the wall of the left ventricle. Occasionally a cardiac infarct undergoes organization into a dense fibrous scar, which may then stretch to form a cardiac aneurysm, with rupture of the sac or detachment of the clot from its inner surface as the cause of sudden death.

Embolism

Embolism of a large branch of a coronary artery or of the orifice of

one artery rarely causes sudden death, the patient usually having been seriously ill for some time. It occurs chiefly in acute endocarditis of the aortic valve, but I have found it in cases of thrombosis in the left ventricle, and of mitral stenosis with thrombosis in the left auricular appendix. An embolus generally produces a distinct local thickening of the artery, and when the vessel is opened the embolus is often pointed and is easily removed intact except when death has not occurred immediately. Embolism may be followed by infarction and the other complications seen in cases of thrombosis.

Very occasionally sudden death is due to compression of one or both coronary arteries by blood from a dissecting aneurysm of the aorta extending to the root of the vessel. Syphilis of the first part of the aorta leading to contraction of the orifices of the coronary arteries may cause sudden death, the coronary arteries themselves being free from disease. Death from this cause sometimes occurs in young subjects. *Compression*

Congenital abnormality of the coronary arteries is a very rare cause of sudden death. The coronary arteries are frequently of unequal size the right usually being the smaller. Occasionally one vessel is extremely narrow, and sudden death may result from comparatively slight disease and narrowing of the other vessel. One artery may even be absent, a condition which was present in a young woman 22 years of age, in apparently perfect health, who died suddenly whilst skipping after lunch. I could not find any trace of the left coronary artery; the right was of average size, and the main blood-supply of the left ventricle was from its descending branch. The greater part of the muscle of the left ventricle was replaced by fibrous tissue. *Congenital abnormalities*

It is not within the province of a pathologist to say whether sudden death can occur from spasm of the coronary arteries, but I have never seen a case of sudden death with a history of anginal attacks in which serious disease of the coronary arteries was not found. *Spasm of coronary arteries*

Finally, coronary artery disease is one of the best examples of the well-known fact that the severity of the disease necessary to cause death varies in different individuals. Exercise or violent exertion, even profound emotion such as anger, as John Hunter realized, may be the determining factor in producing the fatal seizure, but examples of extreme narrowing of the coronary arteries are found in persons who have never had symptoms of coronary artery disease, who have led active lives, and have died from some other cause; similarly thrombosis in one coronary artery, generally the right, which appears often to be of less importance, may not cause death until a serious lesion develops in the other artery. *Individual variations*

(b) *Rupture of the Aorta*

Rupture of the aorta is an occasional cause of sudden death. The rupture is generally in the arch and is seen chiefly in old people with an atrophied and dilated aorta which may be free from atheroma, though rupture may occur through the base of an atheromatous ulcer;

in either event it generally forms a dissecting aneurysm which may rupture into the pericardial or the pleural cavity. Syphilitic aortitis in young subjects may also proceed to dilatation and rupture of the vessel.

(c) *Rupture of an Aneurysm*

Ruptured aneurysms of the larger arteries are obvious causes of sudden death. When aneurysms of the smaller arteries, such as the mesenteric, coronary, or cerebral, rupture into a body cavity, it is sometimes difficult to find the source of the haemorrhage.

(d) *Haemorrhage*

*Into body
cavities*

Other forms of fatal haemorrhage into body cavities can be traced usually to injury of a viscus or of the body wall, to new growths, or to such conditions as ectopic gestation. Occasionally the source cannot be found, as in peritoneal haemorrhage in the new-born, which may be due to tearing of a number of small veins in the omentum from pressure on the abdomen during labour.

*Into
alimentary
canal*

Most of the haemorrhages into the alimentary canal are due to ulcers or new growths, but occasionally the site cannot be found. Considerable haemorrhage in the stomach and intestines may be due to swallowed blood from a lesion in the lung, nose, or nasopharynx. Ruptured oesophageal varices may also be very difficult to find; these are detected more easily if the suspected area is removed and inspected under water.

*In other
sites*

Disturbance of the function of an organ is the explanation of some of the deaths from haemorrhage; this is seen in cases of haemorrhage into the pericardial cavity and in most cases of intracranial haemorrhage, as well as in haemorrhage into the adrenal glands, which occasionally causes unexpected death in infants and still more rarely in adults. Acute haemorrhagic pancreatitis is an occasional cause of sudden death.

(e) *Fatty Degeneration of the Heart*

Fatty degeneration of the heart muscle, i.e. deposition of fat in the muscle cells, is a very important cause of sudden death, as it is of death generally. This condition is more often diagnosed wrongly or missed than any other morbid process.

*Tabby-cat
striation*

Advanced patchy fatty degeneration producing the stippling of the muscle which is called tabby-cat striation is obvious to the naked eye. Post-mortem changes are often the explanation of a soft pale muscle which is described as fatty degeneration, whereas a firm muscle of good colour may be found to show marked fatty degeneration when it is examined microscopically.

*Technique of
histological
examination*

Microscopical examination of the heart muscle should therefore be a part of the routine of a medico-legal necropsy; this can be carried out easily by placing a very thin shaving of the muscle, cut along rather than across the muscle bundles, into a solution of osmic acid for an hour, teasing the fragment finely in Farrant's solution on a slide, covering it with a thin coverslip which is pressed down firmly with a

slight rotary movement so as to flatten out the specimen, and examining it under a high power with a narrow beam of illumination. Fatty degeneration and brown atrophy of the muscle cells can thus be recognized; the fat, however, must not be confused with the irregular-shaped lipid deposits found in decomposition.

Sudden and unexpected death due to fatty degeneration of the heart muscle occurs during or after acute infections, such as latent pneumonia, scarlet fever, influenza, and diphtheria, in severe anaemias (e.g. acute leukaemia), in toxic goitre, in chronic alcoholism and other toxic conditions, in infancy from congenital defects of the heart or blood-vessels, and in acute bronchitis of infants—especially when it is complicated by acute middle-ear disease. Exposure to severe cold or to a high temperature, the passage of a weak electric current through the body, or emotional disturbances may lead to sudden death in those who have severe fatty degeneration of the heart muscle. In fat elderly persons the condition of fatty infiltration of the heart is sometimes found; the visceral pericardium is loaded heavily with adipose tissue which extends between the bundles of atrophied muscle cells. This condition is liable to embarrass the heart's action and may cause sudden death. *Antecedent conditions*

I have already referred to latent acute infections as occasional causes of sudden death; to these may be added chronic nephritis, and Addison's disease of the adrenals in which again enfeeblement of the heart muscle is the immediate cause of death.

In old persons, especially when they are the subjects of chronic disease, the heart muscle may undergo extreme atrophy with pigmentation, i.e. brown atrophy, and sudden death may occur from this cause. This condition or fatty degeneration may lead to rupture of the heart, occurring occasionally through the wall of the right heart. *Brown atrophy*

(f) *Valvular Disease of the Heart*

Valvular disease of the heart is less frequently the explanation of unexpectedly sudden death, except in aortic incompetence and occasionally in acute infective endocarditis.

(g) *Pulmonary Embolism*

Pulmonary embolism is an important cause of sudden death, and is liable to be overlooked from faulty technique or from inability to distinguish between emboli and post-mortem clots. Faulty technique consists in removing the heart from the body separately by division of the vessels at its root. Emboli are thus likely to be cut across, and in any event may fall from the open vessels. The heart and lungs should be removed together and the pulmonary artery and its main branches in the lungs opened from the right ventricle.

The following are the chief differences between emboli and post-mortem clots:

Post-mortem clots in the pulmonary artery are soft and cylindrical and consist of uniform dark-red masses, or of yellow or grey elastic semi- *Post-mortem clots*

translucent clots which may be flattened (the so-called agonal clots), or of combinations of the two varieties. They lie free in the vessels, conforming in shape to, though rather smaller than, the vessels in which they lie. The pale clot often consists of a single mass extending along the main artery and as far as the medium-sized branches in the lungs; and with care such a clot can be withdrawn intact showing the dichotomous branching of the pulmonary artery. The clot is often continuous with a similar mass in the right ventricle, and the impressions of the cusps of the pulmonary valve may be visible on its surface. Post-mortem clots are solid, and when broken or cut across show no typical lamination, but in the mixed forms only the difference in colour between the two portions of the clot.

Pulmonary emboli

Pulmonary emboli have their origin in the systemic veins; they are firmer than post-mortem clots, the consistence depending upon their age, and they tend to be dry and friable; in colour they are generally dark red and the surface is generally picked out by small pale areas, the groups of platelets from which the thrombi developed, giving them a mottled appearance. Their thickness is that of the veins in which they formed, and they are usually much thinner than post-mortem clots. Most of them are cylindrical but less uniformly so; they may taper towards one end which may be bluntly pointed, and rounded swellings are often present along them, especially when they are derived from varicose veins. They frequently have short branches corresponding with the tributaries of the veins of origin but in no way conforming to the branches of the pulmonary artery. Occasionally the impression of a venous valve can be seen upon the surface of an embolus. One of several emboli may be flat and, when placed in water, is found to be hollow, being derived from a marginal thrombus. Emboli do not conform to the vessels in which they are found; they form either riding emboli across the bifurcation of the main pulmonary artery or of one of the larger branches, or they consist of a heaped-up mass of clot wedged tightly into one of the main branches. This latter may consist of several pieces when it is unravelled. Emboli seldom form clean plugs in large branches of the pulmonary artery.

Emboli often consist of a number of short pieces with rough ends showing that they have been broken, probably in their passage through the heart, or there may be a single long clot 9 inches or more in length. Such a clot, in addition to blocking one of the main pulmonary arteries, may extend backwards into the right ventricle and even into the auricle. An unattached piece of a thrombus may be found in one of the cavities of the right heart or in the inferior vena cava. Death usually occurs within a few minutes and the emboli are not adherent to the artery wall. There may, however, be one or more previous attacks before the fatal seizure, and in such cases the older emboli become adherent, and, if a branch is completely closed, secondary thrombosis extends from the embolus along the vessel.

When an embolus is broken or cut across concentric lamination is

generally seen and shows well on microscopical examination, when areas of polynuclear-celled infiltration are found arranged in separate layers. A search should be made for the source of the emboli; it will not be successful if the whole of the thrombus has broken away, but it frequently happens that thrombi are present in some of the tributaries when the main vein is empty. Many of the deaths from pulmonary embolism occur during periods of enforced rest, after severe operations, after labour, in the course of prolonged acute infections such as enteric fever, or as the result of fractures or other injuries, and it is commonly about ten days after an operation that death occurs.

A large vein near an injured area may be the site of the thrombus, or a large tumour or other pressure-producing condition may lead to thrombosis in an adjacent vein; but in many cases there is no morbid condition likely to produce local thrombosis. In such cases the femoral veins are the most probable sites of thrombosis, or the pelvic veins after labour or pelvic operations. Varicose veins in the leg may be the starting points of thrombosis. *Sites of origin of thrombus*

Pulmonary embolism is a rare cause of death under an anaesthetic, the thrombosed vein being situated usually in the area of operation, or in a part which has been pressed upon or manipulated during the operation. The injection treatment of varicose veins has been responsible for an occasional fatality from pulmonary embolism. *Pulmonary embolism*

Lastly, pulmonary embolism is a cause of sudden death in old persons who are in their usual health. A feeble circulation inducing local thrombosis is the usual explanation; if there is no tumour or other cause of local venous obstruction, varicose veins in the legs are the probable site of thrombosis.

Pulmonary embolism causes death from massive obstruction of the pulmonary circulation. In fatal cases more than half the area of the arteries is usually obstructed. Smaller emboli become adherent to the artery wall and they may then enlarge by secondary thrombosis; such lesions may be mistaken for pulmonary thrombi.

Primary thrombosis of the pulmonary artery occurs chiefly over areas of atheroma, which may develop in conditions of prolonged rise of pressure in the pulmonary artery produced by diseases such as mitral stenosis, extensive fibrosis of the lungs, or patent ductus arteriosus when it persists into adult life; the thrombi rarely become so large as to endanger life. *Primary thrombosis of pulmonary artery*

(h) *Functional Disease of the Heart*

Functional disease of the heart is a rare cause of sudden and unexpected death. Death seldom occurs in the first attack, and the patient has generally been under medical treatment; it may be suspected if a thorough post-mortem and microscopical examination of the organs fails to show any serious pathological changes, and if poison is excluded. Hypertrophy of the left ventricle of the heart may be found in these cases.

(i) *Air Embolism*

Air embolism, which at one time was an occasional cause of sudden death during operations on the neck, occurs very rarely now from that cause, but is still seen occasionally in cut-throat wounds, generally when the internal jugular or the common facial vein is opened but not completely divided. Bright red froth is found in the cavities of the right heart and in the pulmonary artery, and similar froth escapes through the wound after death, especially if the chest is compressed. The froth must not be confused with the dark-red frothy blood found when putrefaction is developing, for in the latter condition similar changes are found in the blood in the portal vein and elsewhere. Bacteriological examination will also differentiate the two conditions.

(2)—*Diseases of the Respiratory System*

Respiratory causes of sudden and unexpected death are less frequent than those affecting the circulatory system.

*Oedema of
the larynx*

Oedema of the larynx is one of the commonest causes of sudden asphyxial death; it occurs in acute local infections such as acute laryngitis and acute suppurative processes in the neck, conditions in which the administration of a general anaesthetic is attended by considerable danger; it also occurs from compression of the veins of the neck by tumours or other swellings; it is a cause of sudden death in acute or chronic nephritis and in chronic heart or lung diseases; it is also one of the causes of death in poisoning by corrosives and by irritant gases such as ammonia. Angioneurotic oedema of the larynx is a rare cause of sudden death.

*Acute
oedema of
the lungs*

Acute oedema of the lungs is an occasional cause of sudden death in nephritis, and is one of the results of the inhalation of irritant gases. The changes in the air passages and lungs resemble those of drowning, with an abundance of frothy fluid in the air passages.

*Impaction of
foreign
body*

Sudden death occurs from the impaction of a foreign body such as a mass of food, or in a child a sweet or marble, in the larynx; or by the escape of blood from a tuberculous cavity or new growth in the lung, or from rupture of an aortic aneurysm into a bronchus; or by the regurgitation of vomit into the air passages and lungs in conditions of unconsciousness due to alcoholic excess, cerebral haemorrhage, narcotic poison, or during the administration of a general anaesthetic, especially in conditions of intestinal obstruction or general peritonitis. Ulceration of tuberculous glands into the trachea has also caused sudden death.

*Acute
bronchitis*

Acute bronchitis is a frequent cause of sudden and unexpected death in infants. The post-mortem examination may show little more than slight emphysema of the lungs and frothy mucus in the smaller bronchi, but usually the emphysema is more pronounced and there may be small areas of collapsed lung or of broncho-pneumonia and more abundant secretion in the air passages. The liver and kidneys show cloudv

swelling; signs of asphyxia are sometimes present; in other cases death appears to be due to heart failure.

Acute middle-ear disease is a not uncommon complication of acute bronchitis in infants; it may be the cause of sudden death after the bronchitis has cleared up.

Death from pressure upon the air passages occurs characteristically in hanging and strangulation, and is a fairly common accident in persons falling in an unconscious condition upon a projection such as the edge of a fender. *Pressure on air passages*

Sudden enlargement of the thyroid gland from congestion or haemorrhage, or slight pressure over the enlarged gland, will readily cause death, and tumours in the upper part of the mediastinum occasionally result in asphyxia; but the ordinary enlargement of the thymus gland in children is incapable of causing death in this way.

Congenital heart disease in infants is a common cause of sudden asphyxial death due to the effect of the mixed arterial and venous blood upon the respiratory centres. It is of considerable medico-legal importance therefore as a cause of death in new-born and young infants; the condition is sometimes overlooked and death is attributed to over-laying. A large patent ductus arteriosus is the commonest abnormality and the one most likely to be missed if the heart is separated from the lungs. The ductus should be opened throughout its length; its diameter in fatal cases is little less than that of the aorta. *Asphyxia from congenital heart disease*

The post-mortem changes resemble those of smothering, but without signs of pressure about the face. The body is generally livid, the blood fluid and dark red, and the organs engorged and of a similar colour, with numerous petechial haemorrhages on the surfaces of the heart, lungs, and thymus gland.

Pressure upon the respiratory centres in the base of the brain or in the upper part of the spinal cord by haemorrhage or tumour or by dislocation of the spine may result in death from asphyxia. *Pressure on the respiratory centres*

A young man who died suddenly during the extraction of a tooth, whilst under the influence of an anaesthetic, was found to have tuberculous disease of the cervical vertebrae with a mass of granulations in the spinal canal. Slight displacement of the spine during the operation sufficed to compress the cord without producing gross injury.

Some rapidly acting poisons are chiefly asphyxial in their effects; the more important of these are carbon monoxide, carbon dioxide, the cyanides, and cocaine. *Poisons*

Carbon monoxide is the most characteristic of these poisons; a bright red and fluid blood and bright-red congested viscera and muscles are disclosed by necropsy; the gas can be detected in the blood by spectroscopical examination (see spectra in Vol. II, Plate VI, facing p. 499). *Carbon monoxide*

In carbon dioxide deaths there are found the general changes of asphyxia—dark-red fluid blood and a similar colour of the engorged organs, with no indication of the cause of asphyxia; so that unless the *Carbon dioxide*

circumstances of the death are known it is impossible to say how it has been brought about.

Cocaine The same observation applies to acute cocaine poisoning in which the post-mortem examination does not show any changes to account for death; it results chiefly from the rapid absorption of the drug when applied in strong solution to inflamed mucous membranes or raw surfaces. Death occurs within a few minutes and is preceded by asphyxial convulsions.

Cyanides Hydrocyanic acid and the cyanides are said to paralyse the respiratory centres; they leave a characteristic odour in the body which, however, is neither lasting nor detected with readiness by some persons. The blood and viscera sometimes have a rather bright red colour, not so pronounced as in carbon monoxid poisoning. The bright red and congested mucous membrane of the stomach, and in the case of potassium cyanide even slight corrosion with very alkaline stomach contents, serve to differentiate these from other asphyxial deaths.

(3)—Diseases of the Central Nervous System

Diseases of the central nervous system account for many sudden deaths.

(a) *Haemorrhage into the Central Nervous System*

From rupture of diseased artery Haemorrhage into the corpus striatum, pons, or occasionally into the cerebellum, is one of the most frequent lesions; it is due presumably to rupture of a diseased artery—though the ruptured vessel can rarely be found, and the larger arteries are not invariably diseased. Death can occur instantly, but is usually preceded by a period of unconsciousness; in those who are found dead it is next in order of frequency to coronary artery disease. When the haemorrhage occurs into the corpus striatum it generally breaks through into the lateral ventricle and may appear on the surface as a subarachnoid haemorrhage, generally limited in extent, over the base of the brain. In persons with marked disease of the cerebral arteries, cerebral haemorrhage occasionally causes death as the result of a blow, a fall, or even violent exertion, without any indication of intracranial injury. From the post-mortem examination alone it may be impossible to determine whether the haemorrhage was primary or was secondary to violence or excitement.

From trauma Smaller haemorrhages into the brain are found, occasionally associated with other severe intracranial injuries, in deaths from violence. It is not uncommon to find a large cerebral haemorrhage associated with one or more haemorrhages in the pons, disorganizing that part of the brain to a greater or less extent; it occurs in the more rapidly fatal cases, and the pontine haemorrhages are probably secondary to venous obstruction produced by sudden increase in size of one cerebral hemisphere.

Meningeal haemorrhage Meningeal haemorrhage due to disease or injury is a fairly frequent cause of sudden death.

A typical traumatic haemorrhage is the extradural variety which is

almost always the result of fracture of the skull extending across or along the groove for the middle meningeal artery or for one of its main branches. If the skull is thin at the site of fracture, so that no great violence was necessary to fracture it, the immediate effects of the violence may pass off in a short time but the individual be found dead or unconscious some hours later. The area of separation of the dura mater from the skull is not usually very large, but the clot forms a thick mass which compresses the brain.

Subdural haemorrhages occur either chiefly into the subdural space, in which case they are removed when the brain is washed under the tap, or into the pia-arachnoid, in which case they are not affected by washing. Extensive subarachnoid haemorrhage is almost always produced by disease but it is sometimes mistaken for traumatic haemorrhage.

The commonest cause is rupture of an aneurysm on an artery at the base of the brain. The haemorrhage infiltrates the pia-arachnoid over the greater part of the base of the brain and extends along the Sylvian and greater longitudinal fissures and even over the lateral aspects of the cerebral hemispheres; it also bursts through the floor of the third ventricle and thus extends into the ventricular system. Aneurysms range in size from minute structures little larger than a pin's head to tumours having a diameter of one inch or more; they often form in the angle of bifurcation of an artery; and they occur at all ages, though least frequently in children. The cerebral arteries may be otherwise free from disease.

The larger aneurysms are found without difficulty, but the small ones are concealed from view by the haemorrhage and are often flattened; tiny ones may be completely destroyed when they rupture. To find an aneurysm the arteries should be exposed and carefully separated from the haemorrhage, as far as possible by blunt dissection with the point of the forceps. They are found more easily if the arteries and their main branches are removed and are placed in water in a Petri dish; if this method fails the arteries should be placed in formalin solution for two or three hours. Immersion in fluid after removal of the blood often enables the aneurysm to resume its original form, and after fixing in formalin it does not again flatten. Rupture of a cerebral aneurysm is usually rapidly fatal, death often occurring within a few minutes of the onset of symptoms (see also Vol. I, p. 531).

A larger aneurysm on the anterior or middle cerebral artery may point into the adjacent brain; when it ruptures a fatal haemorrhage is produced in the white matter of the frontal lobe or at the temporal pole with little or no meningeal haemorrhage. A search should be made for a cerebral aneurysm in all cases of fatal haemorrhage in these regions. Cerebral aneurysms are generally considered to be the result of disease or of congenital defect of the artery wall, but the possibility of a traumatic origin should be considered, especially when the arteries are otherwise free from disease.

A boy aged sixteen years was sitting at tea when he suddenly lost consciousness, fell from the chair, and died almost at once. He was found to have a fairly large ruptured cerebral aneurysm and meningeal haemorrhage. On inquiry it was stated that he had sustained a severe head injury in infancy when his perambulator was overturned, and was unconscious for several days. From early childhood he had been subject to attacks of very severe headache for which no cause could be found.

Haemorrhage into the subdural space is generally due to injury. When the blood is washed away one or more local areas of haemorrhage into the pia-arachnoid are likely to be found; the brain tissue beneath these areas is often bruised and softened, either at the site of the blow or in the contre-coup position. The skull is not always fractured in these cases but extracranial injury is almost invariably present. Fatal subdural haemorrhage is due occasionally to a fall in which one or more of the superior cerebral veins are torn close to their termination in the superior longitudinal sinus.

(b) *Meningitis*

Latent meningitis, generally acute, though occasionally tuberculous, is a cause of sudden death; meningococcus infection is the chief form, and the brain may show only flattening of the cerebral convolutions and slight dilatation of the lateral ventricles with slight turbidity of their contents. Obvious inflammation may be found only over the lower part of the spinal cord.

(c) *Internal Hydrocephalus*

Internal hydrocephalus is seldom the cause of sudden and unexpected death except in chronic cases seen chiefly in adults, when the distension of the ventricles is not very great. Death may occur suddenly without warning, but there is sometimes a history of severe headaches having a sudden onset and an equally sudden cessation, or of attacks of giddiness or unconsciousness. The condition may be found without difficulty and its cause ascertained, e.g. a small tumour or cyst in the third ventricle; but in other cases no cause can be found and the hydrocephalus may not be recognized because the cerebrospinal fluid has soaked into the brain after death, leaving the ventricles empty.

Method of examination

To obtain a good view of the lateral ventricles they should be opened from above, drawing apart the cerebral hemispheres and making a longitudinal cut through the corpus callosum on each side close to the mesial aspect of each cerebral hemisphere, and extending the cuts at each end so as to expose the anterior and posterior cornua of the ventricles.

The cerebral convolutions are usually flattened, the skull is thin, and its inner surface finely roughened and excavated irregularly, especially in the base, by the pressure of the cerebral convolutions.

(d) *Tumours, Abscesses, and Cysts*

Tumours, abscesses, or cysts of the brain may cause sudden and unex-

pected death; symptoms may be slight or absent until haemorrhage into a tumour, or the rupture of an abscess or cyst into a ventricle or upon the surface of the brain, produces a sudden redistribution or increase of intracranial pressure. When massive haemorrhage occurs into a soft glioma of the brain the tumour may be concealed by the haemorrhage, and a microscopical examination of the margin of the haemorrhage is then the only means by which its cause can be ascertained. Fatal cerebral haemorrhage situated elsewhere than in the corpus striatum, for which there is no other obvious explanation, should be suspected to be due to a tumour.

Haemorrhage into a secondary tumour in the brain occasionally causes sudden death when the primary growth in the mediastinum or bronchus has not produced symptoms.

(e) *Epileptic Fits*

Sudden death during an epileptic fit is a fairly frequent occurrence and is generally the result of an accidental suffocation or strangulation, of injuries produced by falling, or of burns. No gross changes are found in the brain, and biting of the tongue is inconstant; diagnosis is made, therefore, by the exclusion of other causes of death. In almost all cases there is a history of previous attacks.

(f) *Cerebral Embolism or Thrombosis*

Embolism or thrombosis of a cerebral artery is a rare cause of sudden death unless the ordinary form of cerebral haemorrhage is regarded as due to thrombosis. Thrombosis seldom occurs apart from advanced *Thrombosis* disease of the artery with narrowing of its lumen. Except when the patient lives long enough for softening of the brain to develop, the condition may be missed unless diseased areas in the arteries are cut across systematically.

A cerebral embolus generally blocks a healthy artery and produces a *Embolism* distinct and firm local swelling. The blocked portion of the artery softens and occasionally ruptures with the production of meningeal haemorrhage.

2.—OTHER CAUSES OF SUDDEN DEATH

(1)—Coma: Diabetic and Uraemic

Diabetic or uraemic coma may be rapidly fatal and should be considered in all cases in which the cause of death is not obvious. Examination of the blood and the urine affords the most certain means of diagnosis. Kidneys of rather more than average size and a bladder full of pale urine may suggest diabetes mellitus. It is seldom possible at the necropsy to diagnose uraemia from disease of the kidneys even when microscopical examination of the organ shows advanced disease. *Diabetic and uraemic coma*

(2)—Shock*Definition of shock*

Shock alone is a rare but medico-legally very important cause of sudden death. The word is often misapplied as a cause of death, being used in deaths from heart failure due to obvious causes, or linked up with haemorrhage or brain injury in cases of wounding. In its essential medico-legal application shock implies immediate arrest of function of one of the three master systems—the circulatory, respiratory, or central nervous system, by nervous impulses conveyed from the periphery.

The arrest of function is not of necessity final; if the proper treatment can be applied promptly, many cases will probably be capable of complete recovery. This is well shown by the results of treatment of shock from electrocution in which paralysis of the respiratory centres is often the most serious effect. The prompt application of artificial respiration, maintained sometimes for a considerable time, has resulted in the complete resuscitation of many apparently lifeless victims.

Other conditions of sudden death from shock arise from stimulation of the mucous membrane of the nose and throat or of the larynx, pressure or blows on the epigastrium, and stimulation of the genital organs.

Shock to nose and throat

Death from shock has occurred from operations upon the nose or throat; this danger has been minimized by the use of local anaesthetics. The entrance of a crumb or other small foreign body into the larynx has occasionally caused sudden death from shock, and stimulation of the laryngeal mucous membrane is the probable explanation of sudden death produced by grasping the larynx in the act of manual strangulation.

Immersion

Sudden death from the shock of immersion in water is a fairly frequent explanation, when a dead body removed from the water shows no signs of death from drowning and no other condition to account for death. That these deaths are very sudden is also evident from the fact that occasionally articles which are known to have been in the hands of the victim at the moment of immersion are found firmly grasped when the body is recovered. The immersion in these cases is often unexpected and the victim has entered the water feet first, the shock being produced by the rush of water up the nose.

Pressure on epigastrium

A blow or pressure over the epigastrium has frequently produced death from shock. The mechanism of this form of death is uncertain—namely, whether, as appears to be more probable, it is due to stimulation of the vagus in the stomach wall, a view supported by the fact that the stomach is generally full of food, or whether it is due to the pressure reaching the sympathetic ganglia at the back of the abdomen.

Shock to genital organs

Genital forms of shock are recorded occasionally in the male from crushing injuries of the testicles, but the more important form is that which occurs in pregnant women; this is brought about either by sudden stretching of the cervix of the uterus whilst attempting to pass an instrument into the uterus, or by the sudden stretching effect pro-

duced by injection of fluid into the uterus. These deaths occur with dramatic suddenness and the victim, if she has operated upon herself, will be found lying dead with the articles which she was using close to her body.

With greater experience of this form of shock a certain amount of information has been obtained as to the mechanism by which stimulation of the uterus causes death. Death is not due to primary heart failure, for the heart appears to continue to contract vigorously for a time after the victim has lost consciousness; the cause of the shock is more probably a very rapid fall of blood-pressure due to vasomotor paralysis, with extreme dilatation of the arterioles in a large area of the body. The engorgement of most of the organs and the fullness of the veins, which are the only changes found on post-mortem examination, support that view.

Some of the sudden deaths brought about by the too rapid withdrawal of large volumes of fluid from the body cavities are also probably examples of extreme vasodilatation due to the sudden reduction of pressure. Some of these deaths, such as those induced by paracentesis of the pericardium, are the result of rapid dilatation of the heart. *Shock following paracentesis*

(3)—Status Lymphaticus

Finally, the condition which has been designated status lymphaticus or lymphatism must be included in the contributory causes of sudden and unexpected deaths. Although it has been found occasionally in other forms of sudden death, its greatest frequency is in those which occur during the administration of a general anaesthetic for operations which are generally comparatively slight, such as the removal of tonsils and adenoids, operations upon the nasal septum, extraction of teeth, or circumcision. The victims are generally young subjects, about half the deaths occurring before the fifteenth year, though occasionally it has been found in persons over forty years of age.

Apart from the condition for which operation is required, the victim in a large proportion of the cases is apparently perfectly normal but exhibits to a greater or less degree the changes from which the name is derived, foremost amongst which are overgrowth of lymphoid tissue associated with the alimentary canal: (a) enlarged tonsils and lingual tonsils and the presence of adenoids; (b) enlarged lymph follicles in the wall of the pharynx, in the stomach (especially at the pyloric end), in the small intestine (especially its lower part where the Peyer's patches are conspicuous by their size), and in the large intestine where the changes are less marked or may be absent. The lymph glands associated with these areas are enlarged, especially the mesenteric group, and sometimes those in the neck. *Clinical appearance*

In addition to these structures the thymus is conspicuous, being larger than the average in younger subjects and persistent in older ones. It is also an active lymphoid structure and shows little or none of the replacement by fat which characterizes the atrophying gland. The spleen *The thymus*

also tends to be enlarged and its Malpighian corpuscles are conspicuous.

Occasionally the lymph gland enlargement is more widely distributed and includes such groups as the axillary and inguinal glands. The increase in size of the lymphoid tissue is found on microscopical examination to be a simple hyperplasia and to show no inflammatory changes.

*Morbid
changes in
heart*

Lastly microscopical examination of the heart muscle shows pathological changes in a large proportion of the cases and especially in the younger subjects. The usual condition is fatty degeneration, fine and uniformly distributed, sometimes marked.

These conditions suggest a mild and very chronic toxic process, probably an alimentary toxæmia, the enlarged lymphoid structures being examples of irritation overgrowth. The change in the heart muscle is also toxic, and it is the heart which appears to fail first in fatalities in which this condition is present.

DECIDUOMA MALIGNUM

See CHORIONEPITHELIOMA AND HYDATIDIFORM MOLE, p. 220

DEFICIENCY DISEASES

See DIETETIC DEFICIENCY DISEASES

DELHI BOIL

See LEISHMANIASIS, CUTANEOUS

DELINQUENCY

See PSYCHIATRY OF CHILDHOOD

DELIRIUM TREMENS

See ALCOHOLISM, Vol. I, p. 282

DELIVERY

See LABOUR

DELUSIONAL INSANITY

See PSYCHOSES AFFECTIVE (MANIC AND DEPRESSIVE STATES);
and PARANOIA AND PARANOID CONDITIONS

DEMENTIA PARALYTICA

See NEUROSYPHILIS

DEMENTIA PRAECOX

See SCHIZOPHRENIA

DE MORGAN'S SPOTS

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286.] De Morgan's spots are also known as senile telangiectasis and are designated by the French 'Signe des naevis de Trélat'. Though they must have been very familiar to clinicians for all time, it does appear that Campbell de Morgan (1811-76) was the first to suggest that they are more commonly present in cases of malignant disease and may be an indication of the presence of that malady; but this association still awaits proof. *Definition*

These 'ruby spots' are like tiny angiomas, seldom more than one-eighth to one-quarter of an inch in diameter. They are raised above the surface of the skin and do not disappear on pressure, both of which features put them in some category different from that of the ordinary angioma. *Clinical appearance*

They are usually situated about the abdominal wall and especially near the umbilicus, but they may be found over the chest, on the back, and more sparingly on the proximal portions of the extremities. The numbers present vary very considerably, and whereas there may be only three or four visible on the front of the body, on other occasions there may be four or five times that number. *Distribution on the body*

They are very common in people of advancing years, and probably most of those who have looked into the question do not now consider that they have any other association with malignant disease except that the ages of incidence of both conditions coincide. Nor is there evidence that they are especially prone to occur in those suffering from chronic myocardial weakness, although this has been suggested. *Association with other diseases*

According to Sampson Handley, De Morgan's spots are probably a purely senile change without any significance other than as an imprint of the finger of time; in 1909 he produced evidence to show that histologically they represent an invasion of the epithelial layer by connective tissue which becomes vascularized, so that the fully developed spot consists of a mass of dilated capillaries with a network of supporting connective tissue. *Histological structure*

The spots never seem to give rise to symptoms such as irritation or ulceration, nor do they call for treatment; but occasionally their presence, when noticed by a nervous patient, causes psychological disturbance. The main duty of the attendant is to reassure the patient, *Significance of the condition*

for there is no justification for ever raising the question of their possible connexion with malignant disease or other troubles.

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DENGUE

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Reference may also be made to the following titles:

ARTHROPODS AND DISEASE INFLUENZA
PHLEBOTOMUS FEVER

1.—DEFINITION

287.] Dengue is a short fever with a very low mortality, and caused by a special filter-passing virus which is conveyed from man to man by *Aëdes (Stegomyia)* mosquitoes. Other features which are usually included in definitions of dengue are: (1) the presence of a rash, (2) a two-phase temperature curve, and (3) severe pains; but none of these manifestations is of constant occurrence. In some cases even the fever is so slight that the attack is overlooked.

When dengue occurs in great epidemics, the whole life of the affected community may be disorganized for a time; even armies may be completely immobilized for a few days. Sporadic attacks are painful and temporarily crippling, but otherwise are not of much importance as the disease is rarely fatal.

2.—AETIOLOGY

Dengue has been proved to be communicable from man to man by the bite of the *Aëdes aegypti (Stegomyia fasciata)* mosquito; other species

of *Aedes* may also be effective vectors. Some monkeys are susceptible to the disease and in rare cases may possibly be animal reservoirs of infection.

The virus is ultra-microscopic and filter-passing; it exists in active form in the blood of the infected person during the first three days of the disease and about one day before the onset. The vector mosquito cannot become infected unless it bites the patient during this period of about four days. When the vector has fed on an infected patient it does not at once become capable of conveying the disease to a susceptible person but does so after about eleven days have elapsed; evidently the virus undergoes a cycle of development in the body of the insect. A mosquito which has once become infected remains so for the rest of its life and therefore continues for long periods to be capable of conveying the disease to man.

*Relation to
other diseases*

Dengue is a member of a group of diseases which are caused by filter-passing viruses. Its nearest relation from the clinical point of view is sandfly fever (phlebotomus or papataci fever) which in many cases cannot be distinguished from dengue on clinical grounds and certainly belongs to the same disease-group. Yellow fever is very closely related to dengue, but differs in having a considerable mortality and a much more restricted distribution.

Influenza is now regarded as due to a filter-passing virus which is conveyed from man to man by droplet infection and usually causes catarrh of the respiratory tract; otherwise the disease manifestations of uncomplicated influenza are very similar to those of dengue.

Epidemiology

Most of the accounts of dengue lay great stress on its tendency to occur in great epidemics during which most people in the affected locality are attacked within a few weeks or even days. Too little notice is taken of the less dramatic forms of dengue which occur as sporadic cases in places where the disease persists in endemic form. In many places near the equator conditions are favourable to the activity of the vector mosquitoes throughout the year, and therefore the populations are constantly exposed to infection; in such places a large proportion of the inhabitants have acquired immunity from previous attacks so that the only people who are highly susceptible are new-comers from non-infected localities, and young children who have hitherto escaped the disease. In such circumstances a great epidemic cannot occur.

*Seasonal
incidence*

In sub-tropical climates the conditions are favourable for transmission of the disease only during the warm season and the infection may be carried over to the following hot weather by hibernating infected mosquitoes. In countries which have a brief hot season the infection may die out altogether even though *Aedes* mosquitoes are abundant and active during the warm weather. When conditions like these prevail the population may become completely susceptible owing to the long-continued absence of the disease, so that if the virus is introduced in an infected human-being or mosquito the disease is liable to spread like wild-fire during the period of activity of the vector mosquitoes.

Dengue may therefore occur either as an endemic and sporadic disease or as an epidemic.

The geographical distribution corresponds very closely with the distribution of the vector mosquitoes. In tropical areas dengue should always be taken into consideration as being likely to occur at any time. Crowded populations in coastal and riverine areas are most affected, but wherever *Aedes* mosquitoes are present and active dengue is liable to occur either as an endemic disease or in sharp epidemics according to circumstances. *Geographical distribution*

Dengue is essentially a disease of low levels, but in the tropics it may occur at heights up to 5,000 feet or more, but only during the season when *Aedes* mosquitoes are present and active. *Altitude*

The sexes are equally affected. Young children are said to suffer less frequently than adults, but they have no real immunity and often suffer from severe attacks. *Sex and age incidence*

There is no racial immunity, but, as is the case with yellow fever, indigenous populations often have a considerable degree of immunity which has been acquired through previous attacks. *Immunity*

Immunity is complete for a brief but variable period after recovery. Second attacks sometimes occur a few weeks after the first, but they are usually mild as the immunity does not disappear completely within a short time; as a rule it lasts long enough to protect the person for about a year. Third attacks are not uncommon, but very few people suffer more than three times; evidently each succeeding attack helps to build up a stable and lasting immunity.

Exceptionally the second or later attacks may be more severe than their predecessors. Persons who have a partial degree of acquired immunity are liable to suffer from very mild attacks which can hardly be recognized but are of importance in maintaining both infection and immunity. These 'inapparent' forms of the disease are probably quite common in places where the disease persists in endemic form.

3.—CLINICAL PICTURE

The variability of the disease has been mentioned; this feature is of paramount importance, as anyone who expects dengue always to conform to the type seen or described in one outbreak is extremely likely to miss cases of the disease which have different symptoms. Over and over again accounts have appeared of 'new' diseases which prove to be really forms of dengue.

The incubation period is usually four to seven days, its extreme range being from three to fourteen days. *Incubation period*

Fever is the one and only manifestation which is constantly present in the obvious forms of dengue, but the temperature curve is far from uniform in type. A rapid initial rise and a return to normal in less than seven days are almost invariable features, but the fever may be as *Types of temperature curve*

short as 24 hours or it may last two to seven days; attacks of fever lasting more than seven full days are rarely dengue.

The student of dengue should obtain a clear mental picture of the following types of temperature curve, to one of which most cases conform.

*Continued
fever type*

(1) The continued fever type with 'terminal rise' (Fig. 69A). This is not very common. In it the temperature usually falls slightly after the maximum has been reached and rises again by a degree or so during the last day of the fever.

*Saddle-back
type*

(2) The saddle-back type (Fig. 69B). This is a fairly common type. The temperature curve indicates that the disease has two phases, but in this type the first phase of the fever does not come to an end till the second phase begins, usually on the fourth or fifth day. The second

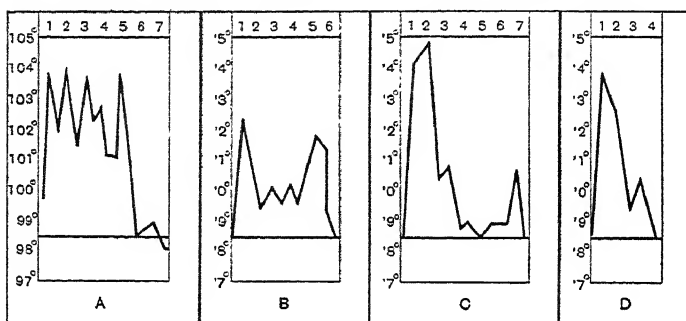


FIG. 69.—The four types of temperature curve commonly seen in dengue. All are from cases of experimentally produced dengue. A is after Ashburn and Craig; B, C, and D after Siler, Hall, and Hitchens. (From *Tropical Medicine*, by Rogers and Megaw)

phase is cut short by the establishment of immunity before the end of the seventh day.

*Interrupted
fever type*

(3) The interrupted fever type (Fig. 69C). This is also fairly common; it differs from the saddle-back type only in that the first phase has come to an end and the temperature has reached normal before the second phase begins.

*Short-fever
type*

(4) The short-fever type (Fig. 69D). In many outbreaks, especially in countries where the disease is endemic, this is the commonest type; it gives rise to many errors on the part of medical men who have been misled by the accounts of dengue which describe a second rise of temperature as a characteristic and diagnostic feature of dengue. In this short-fever type the fever lasts from one to four days, and apparently immunity becomes established before the second phase of the disease has had time to make its appearance.

*Exceptional
types*

In addition to the cases which conform generally to one of the above four types, there may, exceptionally, be irregular forms such as curves showing a step-like rise (Fig. 70A) or curves lasting more than seven days (Fig. 70C), or cases showing three phases; but in the experimentally produced disease and in cases observed in epidemics the vast majority

of the temperature curves show a rapid onset and a fall to normal in less than seven days.

The tendency of dengue to show a second phase is striking and suggests an analogy with relapsing fever, but in both of these fevers immunity often becomes fully established before the second spell of fever becomes due.

During the 24 hours preceding the onset, the patient sometimes feels out of sorts, and if the temperature is taken a slight rise may be detected. *Prodromal symptoms*

The onset is usually quite definite and sudden, even when prodromal symptoms have occurred. Very often the patient can fix the time of onset within a few minutes. The usual symptoms are supra-orbital headache with pains in the back and limbs. Chilly feelings are common, *Onset*

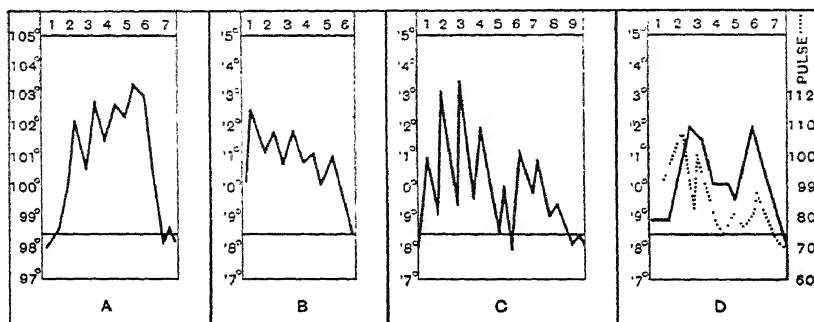


FIG. 70.—A, B, and C are atypical forms of temperature curve; D illustrates the relatively slow pulse (dotted line) of a typical case. (From *Memorandum on Medical Diseases in Tropical and Sub-Tropical Areas*, 1930; and *Tropical Medicine*, by Rogers and Megaw)

but a real rigor is exceptional. Sometimes a red flush is seen over the face, neck, upper part of the chest, and fauces. This so-called primary rash is more often than not of brief duration, but occasionally it is so vivid as to suggest scarlatina.

Within 12 to 24 hours the patient is definitely ill: the temperature has reached or nearly reached its maximum (102° to 105° F.); the headache is troublesome but most patients complain chiefly of tormenting pains in the back and limbs. Real coryza is quite uncommon, but otherwise the early symptoms strongly suggest influenza. The pulse is accelerated at the onset, but within a day or two becomes slower than would be expected from the height of the temperature. *Early stage*

The stage of high fever may last for a few hours or up to three to four days, but after reaching the maximum in 24 to 36 hours the temperature usually falls slightly each day so that by about the fourth day it has often come down to normal or nearly to normal and all the symptoms have abated to a corresponding degree. Quite exceptionally the fever is of the continued type throughout its course. Not infrequently the disease comes to an end with the first fall of the temperature, but in many cases there is a second spell of fever which resembles the first; *Stage of fever*

the headache and pains return but the pulse is usually much slower than would be expected from the height of the temperature (see Fig. 70D).

The second spell of fever comes on the fourth to sixth day and usually lasts one or at most two days, so that the whole febrile period as a rule is not more than six days in duration and rarely lasts as long as seven full days. The fever in this second spell ends by crisis, the temperature falling rapidly to normal or subnormal and the pulse becoming abnormally slow. With the fall in temperature the pains and headache usually disappear, but there is often a good deal of depression which may last for several days.

Secondary rash

The secondary rash is sometimes described as the 'true' rash: it comes usually about the same time as the secondary rise of temperature and lasts for a few hours up till two or three days. It varies greatly in intensity and character and may occur in as few as 10 per cent of the cases or in as many as 90 per cent. Usually it is measly or scarlatiniform in type. The limbs and trunk are the chief sites but the palms are often affected. Desquamation may follow when the rash has been intense, and itching of the palms is sometimes complained of.

Changes in the blood

There is a progressive fall in the number of polymorphonuclear leucocytes in nearly all cases; by the fifth or sixth day the total leucocyte count may be only 3,000 to 4,000 with a relative, but not total, increase of the mononuclears. Nausea with or without vomiting occurs in some cases at the onset, loss of appetite and constipation are usual symptoms. The lymphatic glands are sometimes enlarged and in rare cases the spleen may be palpable. Albuminuria is rare, though 'febrile' albuminuria occurs in a few of the cases in which the temperature is exceptionally high. Insomnia and depression are common features. Delirium has been observed in some cases, but is seldom of grave significance.

Other symptoms

Complications

A long list of complications might be given, but in reality the disease is remarkably free from serious complications.

Sequelae

Depression is a common sequel, and may even approach to melancholia. Exceptionally the pains may persist for some days or even weeks after the fall of the temperature.

4.—PROGNOSIS

Convalescence is usually uneventful, but weakness and depression often delay complete recovery.

Mortality

Among previously healthy persons the death rate is almost nil. The disease is dangerous only to patients already debilitated and to the very old or the very young. In large epidemics the death rate is usually about 0.2 per cent.

5.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Diagnosis presents little difficulty when the disease occurs in epidemics; indeed during epidemics it is necessary to guard against the tendency to assume that every case of fever is one of dengue. Sporadic cases of dengue are frequently regarded as some other disease. In doubtful cases the chief points to be borne in mind are that dengue is extremely variable in its manifestations and that it often occurs in localities where its existence has never been suspected. When there is no characteristic feature, such as rash or two-phase type of temperature, the diagnosis of dengue must be made by a process of exclusion. When the attack conforms to the following criteria it may safely be regarded as belonging to the 'dengue and sandfly fever group', and the differential diagnosis between the two members of the group can then be attempted. (1) The fever is of less than seven days' duration and has a temperature curve resembling one of the types already described. (2) No parasites can be found in blood smears or cultures. (3) There is no leucocytosis but usually a progressive leucopenia. (4) There are no local manifestations such as are found in conditions like influenza, tonsillitis, and septic infections. (5) The mortality is negligible. (6) There is no pronounced nephritis or jaundice. (Points 5 and 6 exclude yellow fever which may conform to all the other criteria.) (7) The fever occurs in conditions compatible with the spread of infection by mosquitoes or sandflies.

Cases of fever which comply with these conditions should never be regarded as a new disease unless very cogent reasons exist for excluding the diagnosis of dengue or sandfly fever.

In an outbreak of considerable size there is seldom any difficulty in the differentiation of dengue from sandfly fever; in sandfly fever the prevailing insect is the sandfly, and there is very rarely a secondary rise of temperature or a rash. In sporadic cases the differential diagnosis may be quite impossible, as many cases of dengue have a fever of two to four days' duration without any secondary rise of temperature or rash, and thus are not distinguishable on clinical grounds from sandfly fever. From the point of view of the patient this 'doctor's dilemma' is of little importance; the diagnosis and treatment are the same in both cases. *Diagnosis from sandfly fever*

Fortunately the distribution of yellow fever is far more restricted than that of dengue, so that in India and other eastern countries no difficulty will arise. Yellow fever is usually much more severe than dengue; jaundice and albuminuria are seldom absent. Very mild sporadic cases of yellow fever may be quite indistinguishable from dengue on clinical grounds, but the mouse-protection test will always settle the question in doubtful cases. *From yellow fever*

Uncomplicated influenza may resemble dengue very closely indeed, but the catarrhal symptoms and the manner of spread are usually enough to settle the diagnosis. *From influenza*

- From measles* The pronounced catarrh, the Koplik's spots, the age distribution, and the spread of the disease in a manner suggesting droplet infection are special features of measles.
- From smallpox* Smallpox may be very like dengue till the eruption appears, but a general consideration of the concomitant circumstances, such as the local prevalence of one or other of the two diseases, will usually help till all doubts are set at rest by the further progress of the disease.
- From other fevers* Scarlet fever, fevers of the typhus group, rubella, malaria, and enteric fever may give rise to difficulty during the first few days. A humiliating mistake is sometimes made by pronouncing the case to be one of enteric fever because the temperature has risen higher than ever on the sixth or seventh day: the patient is sent off to hospital and the temperature promptly falls to normal. This mistake will rarely be made if seven full days of fever are allowed to elapse before dengue is excluded. Blood cultures will, of course, usually settle the diagnosis if the patient has enteric fever.
- From seven-day fever of Japan* Seven-day fever of Japan and other allied leptospiral diseases have often been mistaken for dengue as the temperature curves may be like those of dengue. These fevers can be distinguished by blood cultures and animal inoculation. When albuminuria and leucocytosis are features of the disease dengue can safely be excluded.

6.—TREATMENT

- Drugs* It may be necessary to give small doses of aspirin to relieve the distressing pains, but depressant drugs should be avoided, especially just before the crisis when collapse is liable to be accentuated by aspirin or even quinine. Harmless placebos should be given to patients who are demoralized by the pains. Local applications, such as camphorated oil or belladonna liniment, are useful. No food need be given for the first day or two unless the patient clamours for nourishment. Solid food may be given as soon as the appetite returns unless the temperature is still high. In convalescence the diet should be generous to counteract the tendency to depression. The patient should have plenty of water to sip. Alcohol should be avoided except in the case of addicts.
- General measures* Cold sponging is needed if the temperature rises above 105° F. or if it persists above 104° F. for more than 24 hours. An important point is that the patient is often acutely conscious of being very ill, so that the doctor must combine sympathy with encouragement, otherwise he may lose the patient's confidence by conveying the impression of not taking his case seriously.
- Prevention* Prevention consists in mosquito control on the same lines as in yellow fever. The patient should be kept under a mosquito net for the first three days to prevent the local mosquitoes from becoming infected and spreading the disease to others.

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DENTAL SEPSIS IN RELATION TO SYSTEMIC DISEASE

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Reference may also be made to the following titles:

ARTHRITIS	FIBROSITIS
DENTITION	IMMUNITY AND IMMUNIZATION

1.—INTRODUCTION

288.] The relation between dental sepsis—which includes infection of the teeth and associated tissues—and infections of remote organs and tissues has received much attention in recent years. The importance of the subject arises in large measure from the widespread prevalence of dental or oral sepsis. Dental caries is one of the commonest diseases of mankind, and if, in addition to its incidence, account is also taken of its chronicity and the neglect of its treatment, it may even be regarded as the most prevalent of all. But dental caries in itself may form only a small part of the total oral sepsis. Indeed, it is only when the pulp of the tooth is reached, and eventually is subject to putrefactive processes, that much septic material can be absorbed; and even this does not amount to a great deal. But there are two sources of sepsis which are

of clinical significance—namely, infection of the tissues around the apex of the tooth and infection of the parodontal tissues quite apart from dental caries.

It is an interesting fact that although a connexion between dental sepsis and systemic disease has been assumed for many years, the view that there is such a connexion rests mainly on a clinical basis. Organisms similar to those common in the mouth have been identified in other parts of the body, and in some cases the same organisms have been found both at the dental focus and at a remote site of infection. Endocarditis has been induced in rabbits by injecting into them organisms found in the human mouth.

Perhaps the largest volume of evidence is derived from results of treatment. But even these are inconsistent or even conflicting. Thus, in some cases striking systemic effects have followed the removal of a small septic focus; in others, the elimination of a large amount of sepsis has failed to achieve any systemic result. When, as sometimes happens, a considerable amount of sepsis does not produce any remote results, the reason may be in the resistance of the individual or in the absence of other predisposing causes. Thus, it is well known that septic foci which do not cause any apparent ill-effects in youth or early middle age may make their presence felt in or about the fifties.

Everyday clinical practice throws less light on the problem than might be expected. What ordinarily happens is that patients suffering from disease which may be of septic origin are examined with that assumption in mind, and, dental sepsis being exceedingly common, the practitioner seldom has difficulty in finding it. Even the least significant manifestations of oral sepsis are assumed to have a causal relation to the systemic disease under investigation—and this view persists until removal of the sepsis fails to produce any systemic effect whatever. A more scientific method would be to take a sufficiently large random sample of the population, examine it for oral sepsis and systemic disorders, and correlate the two by statistical methods.

A distinction must be made between immediate local effects of dental sepsis—necrosis, pharyngitis, adenitis, or even thrombosis of the cavernous sinus—and remote effects. In the former there is direct spread of the pathological process; in the latter the infection can only have been conveyed to the remote organ or tissue by way of the blood-stream. It is of course only in the latter that there can be a reasonable doubt as to the relation between the local condition in the mouth and the condition elsewhere in the body.

Local and remote effects of dental sepsis

2.—COMPARISON OF 'CLOSED' AND 'OPEN' INFECTIONS

It is usual now to regard these so-called 'closed' infections at the apex of a root as more important than the more or less open infection of

parodontal disease. This belief rests on a slender foundation. It supposes that the toxin from an open infection is swallowed and in large part destroyed in the stomach, whereas the toxin from the closed infection is assumed to be absorbed by the blood-stream. Neither the one supposition nor the other is necessarily correct. It is probably true that remote local conditions, such as arthritis or endocarditis, are more often associated with an apical than with a parodontal infection; but in my experience it is in association with pronounced parodontal disease that there occur general systemic disturbances—e.g. toxæmia characterized by physical fatigue, mental lassitude, a pallid greasy skin, digestive disturbances, and in some cases ill-defined neuritis and fibrositis.

*Significance
of hypo-
chlorhydria*

No doubt the hydrochloric acid in the stomach can destroy large numbers of organisms and their products, but the amount of septic material that can be produced by deep pockets round twenty or thirty teeth is very considerable. Moreover, in a small proportion of persons achlorhydria or hypochlorhydria is a normal phenomenon consistent with good health under normal conditions; and such deficiency of hydrochloric acid also occurs in pernicious anaemia and is, according to Hurst, frequent in rheumatoid arthritis. It is reasonable to suppose that the constant swallowing of septic material is at least a contributory factor in the causation of such conditions as gastric ulcer, duodenal ulcer, cholecystitis, and appendicitis.

*Effects of
peri-apical
infection*

Peri-apical infection frequently does not cause any signs or symptoms, and cannot be diagnosed without the help of radiographs. Unfortunately the fact that radiographs are essential has led to an exaggeration of their value as a means of diagnosis. It is often forgotten that they do not demonstrate tissue or structure, but only a relative degree of opacity to the X-rays. At the end of a root there may be a blind abscess, a granuloma, a cyst, or rarefaction or sclerosis of bone to a varying degree or extent. Radiographs do not provide an infallible diagnosis, nor is there unanimity about the clinical significance of an assumed change. Weston Price regarded a granuloma as a bar to infection and an agent for destruction of organisms, and considered that a large zone of rarefaction indicated a high degree of local resistance to infection, and that a zone of sclerosed bone surrounding an area of rarefaction indicated lowering of resistance which was formerly high. On the other hand, Stanley Colyer regarded a granuloma surrounded by a well-defined layer of bone as an encapsuled mass probably harmless. He also described signs of deep infection in the bone. The problem bristles with difficulties.

*Interpretation
of
radiographs*

Before attempting to lay down some general lines on which treatment of dental sepsis may proceed, it will be well to refer briefly to some of the more common infections clinically connected with it.

3.—CONDITIONS ASSOCIATED WITH DENTAL SEPSIS

Secondary parotitis should be regarded as a direct infection and is *Parotitis* not common.

Arthritis and fibrositis, because of their frequency, are, in the aggregate, the most important group of diseases associated with sepsis. In no group has the result of removal of dental sepsis been less consistently satisfactory; this is perhaps due to the difficulty in arriving at a diagnosis between those forms of so-called rheumatism which are infective in origin, and those which are due to metabolic disturbances or other causes. *Arthritis and fibrositis*

Goadby relied upon a blood-count and estimation of haemoglobin content as an indication of streptococcal infection of the blood, and upon bacterial examination of the mouth, urine, and faeces. *Remote associated conditions*

Affections of the circulatory system, endocarditis, myocarditis, arteriosclerosis, and phlebitis, have been associated with dental sepsis. *Diseases of circulatory system*

Diseases of the blood-forming organs were among the first to be ascribed to dental sepsis on account of the pioneer work of William Hunter, who believed that the secondary anaemia accompanying pernicious anaemia was due to oral sepsis. *Diseases of the blood-forming organs*

Peripheral neuritis may be due to dental sepsis. Neurasthenia and mental depression are associated with sepsis. Cotton believed that various forms of insanity are due to sepsis, and Bulleid found that dental treatment gave the best results in toxic exhaustive psychoses rather than in melancholia or fundamental psychoses. *Nervous disorders*

There is strong clinical evidence that many eye diseases, such as iritis, irido-cyclitis, keratitis, choroiditis, and optic neuritis, are due to sepsis, and Barber ascribes many skin diseases to the same cause. It is important to remember that in all these conditions there may be other septic foci apart from the teeth. *Diseases of the eye and skin*

4.—BACTERIOLOGY

There is no specific organism responsible for these various local and remote effects. Glynn concluded that the streptococci are the chief pathogenic organisms in periodontal, parodontal, or apical conditions, and that the most frequent are *Streptococcus salivarius* and *S. viridans*. Haemolytic organisms are the exception. The *Bacillus fusiformis* and the *Treponema vincenti*, which apparently occur in symbiosis, are the usual accompaniment of Vincent's angina and ulcerative stomatitis. Bacteriological evidence may be valuable, especially when the same organisms can be identified in local and remote situations; and in those cases particularly the use of a vaccine may be considered, although the extreme difficulty of isolating organisms from part of a

tooth without contamination by other mouth organisms should not be forgotten. Rosenow's theory of elective localization is not generally accepted, especially by those who credit the particular tissue with the elective affinity rather than the organisms.

It is impossible to lay down hard and fast lines for treatment of cases of dental sepsis. Each case must be judged on its own merits, and the age factor is important.

5.—DENTAL DISEASE IN CHILDREN

Constitutional and remote effects do not occur nearly so frequently in children as in adults. Parodontal disease is extremely rare. Abscesses form in connexion with dead deciduous molars, which, however, are soon lost; but chronic apical infection comparable with what occurs in connexion with permanent teeth does not happen.

*Effect on
nutrition*

Children with a considerable number of carious deciduous molars, some of them dead and accompanied by abscesses, suffer from malnutrition caused by defective mastication and septic absorption. Efficient mastication is very important for growing children during the period of function of the deciduous dentition from two and a half to seven years of age, and it is not always realized that one or two molars with exposed pulps may cause a child quickly to acquire the habit of swallowing solid food without mastication.

*Associated
inflammation
of glands*

But the chief effects of infected teeth in young children are local. Inflammatory enlargement of the glands below the mandible and in the neck is extremely common, and is much more often due to septic deciduous teeth than to any other cause; such glands probably have a lowered resistance to tuberculous infection. It is reasonable to suppose that infection of the tonsils is more likely to arise in a mouth with a large number of septic teeth than in a healthy mouth. Acute ulcerative stomatitis in children almost always starts around a dead and septic deciduous tooth.

*Treatment
for deciduous
teeth*

The treatment for septic deciduous teeth is removal. Unfortunately this treatment is not without its ultimate ill-effects. The permanent molars are liable to move forward, so that the premolars or canines are crowded out of position. The resulting condition is not merely of aesthetic importance, but may, if untreated, seriously affect function in later life. Such forward movement of the molars should be prevented by the use of splint-plates, which also provide the child with a masticating surface pending the eruption and functional use of the permanent teeth—perhaps for a period of four or five years.

6.—DENTAL SEPSIS IN ADULTS

*Treatment of
dental sepsis*

The effects of dental sepsis are least evident during young adult life and early middle age, presumably because the powers of resistance are then

greater; but, at the age of about fifty, teeth which have hitherto not caused any obvious ill-effects must often be considered in relation to constitutional or remote affections which have gradually appeared. It is not easy then to decide to what extent remedial treatment in the mouth is possible and permissible, or whether teeth should be extracted, and if so, how many, and which teeth.

Clinical and radiographic evidence should be considered together. For some parodontal conditions clinical evidence alone may be convincing enough, but radiographic evidence alone is seldom conclusive. The details of interpretation cannot here be discussed, but it is necessary to enter a warning against a too definite interpretation of areas of rarefaction around the apices of roots, and it is even necessary to remark that an apparent area of this kind near the apex of the second premolar tooth in the mandible may be the mental foramen. Dead teeth are sometimes condemned on insufficient grounds: they may be harmless. Artificial crowns are sometimes regarded with horror as inevitably noxious. This attitude is somewhat unintelligent. A solid crown fixed to a healthy root may be more innocuous than an innocent-looking dead tooth with a comparatively small filling. The treatment must be defined in relation to the importance of the presumed effects of the sepsis. The sepsis may be only one cause of such a condition as an arthritic joint. Metabolic disturbance, slight injury, and other little known factors of impaired resistance, may be contributory causes, and the age of the patient must be taken into account.

Apical infection is usually treated by extraction, with or without curettage of the infected bone, but apical resection is said to be successful by many practitioners, and ionization by others. Such remedial measures are more applicable and more justifiable with front teeth than with back ones. Parodontal disease when far advanced is incurable. In its early stages it may be cured by local treatment, including ionization, though the original condition can never be quite restored. Even in later stages similar treatment, together with elimination of 'pockets' with the knife or electric cautery, may, if followed by appropriate hygienic measures by the patient, practically eliminate 'open' sepsis. In really advanced cases with much suppuration extraction is the only possible treatment. When the bone is infected to any appreciable depth, considerable time is necessary for elimination of infection by absorption of bone and reaction of the tissues. There is something to be said for the removal of inter-dental processes of the alveolus and the margins of sockets at the time of operation, but the curettage of large areas of bone is of doubtful utility. Some forms of parodontal disease, usually those without signs of local inflammatory reaction or pus formation, are probably not really local diseases so much as local manifestations of a constitutional condition, which may itself be associated with other local affections, and to which treatment should be directed.

*Treatment of
apical
infection*

7.—DENTAL SEPSIS IN OLD AGE

With the advance of old age sepsis is probably rather less important. Certainly many old people with loose septic teeth seem to be none the worse. Coincidentally the operation of removing such teeth becomes more formidable, and the fitting of artificial dentures may present many difficulties. A patient who has lost a certain number of teeth in middle life and has become accustomed to partial dentures seldom has much difficulty in accommodating himself to larger dentures in later life. But a patient who has a large number of teeth extracted in middle life or, worse, in old age, sometimes has considerable difficulty. It is often assumed that the adaptation of artificial dentures has reached such a degree of proficiency as to make the loss of natural teeth of little consequence. This is far from the truth. No artificial teeth are as efficient for mastication as natural ones, although they may be adequate under fairly favourable conditions. Most people can be made reasonably comfortable, and it is indeed rather remarkable that this should be so, because the gums are not naturally adapted to withstand the severe pressure of mastication; but a certain number of people, either on account of unduly sensitive gums, or because of a conformation of the alveolar arches which makes retention difficult, are never really comfortable or able to masticate properly. If it so happens that such a person has been persuaded to have a large number of teeth extracted as part of the treatment for arthritis or some other affection, and no benefit has resulted, the last state of that patient is worse than the first, and the dental surgeon is more likely to be the recipient of caustic comments than the medical practitioner who may have advised the treatment.

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DENTITION

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Reference may also be made to the following titles:

CHILD HEALTH AND WELFARE

DENTAL SEPSIS IN RELATION TO SYSTEMIC DISEASE

289.] The eruption of the teeth, temporary or permanent, may be regarded as an essentially physiological process; but although the diagnosis of 'teething' as an explanation of various disturbances in infancy and early childhood should only be made with the greatest caution, it is going too far to stress the physiological nature of the process to the extent of denying that any disorders of health can be directly or indirectly attributed to dentition. Still aptly pointed out that pregnancy is equally a physiological process in which various bodily disturbances occur, sometimes even of a serious nature.

1.—NORMAL DENTITION

The time at which the teeth erupt varies within fairly wide limits, and the tendency to moderately early or late dentition is often familial, as are also variations from the normal programme. Of the temporary or

'milk' teeth, the lower central incisors appear first, usually between the end of the sixth and the eighth months. Next follow the upper incisors, central and lateral, and then the lower lateral incisors, giving eight teeth at the end of the first year. Thereafter, each six months period up to the age of two-and-a-half years sees the eruption of four teeth: the first molars between twelve and eighteen months, the canines next between eighteen and twenty-four months, and the second molars in the beginning of the third year. The permanent teeth follow a programme which is not so settled: the six-year-old molars are usually the first to appear, followed or accompanied by the lower central incisors. With the appearance of the twelve-year-old molars the permanent set is complete save for the 'wisdom' teeth.

*Normal
accompanying
disturbances*

It is difficult to draw the line between the accompaniments of normal dentition and the disturbances of health which may be regarded as pathological. A breast-fed, healthy baby will often cut his teeth with a minimum of troubles, among which increased salivation (often from the third month), nocturnal restlessness, and a temporary anorexia may be classed as almost constant. It is a clinical observation that such disturbances may occur some weeks before the tooth actually appears to pierce the gum, and it has been suggested that the tension over the periosteum of the jaw may be as painful as, if not more painful than, that experienced later in the softer tissues of the gum.

*Methods of
assisting
dentition*

Normal dentition may be rendered as easy as possible by insistence upon breast-feeding, the provision of a hard substance upon which the baby may bite (a bone ring, clean chicken-bone, or crust), and the local application of liquid paraffin containing a mild local anaesthetic. The following is a suitable prescription:

Menthol	-	-	-	-	-	5 grains
Liquid paraffin	-	-	-	-	-	to 1 fl. ounce

Rub one drop into the affected gums.

2.-PREMATURE DENTITION

*Congenital
teeth*

Babies are occasionally born with one or more teeth. These may sometimes be supernumerary or represent premature eruption of milk teeth. An X-ray examination of the jaw may help to settle this point. If truly supernumerary, these teeth are best removed as the effect upon the nipple may be disastrous; and an actively sucking baby with lower central incisors may also develop a troublesome degree of sub-lingual ulceration. Dentists are against extraction if congenital teeth are in fact early milk teeth, because malocclusion in the temporary set so often means trouble with the permanent teeth. The use of a rubber nipple-shield in these circumstances may prove useful to protect a nursing mother.

*Early
eruption*

Early eruption of the teeth (before the fifth month) is said to occur in congenital syphilis.

3.—DELAYED DENTITION

As already mentioned, there is not uncommonly a familial tendency towards late dentition and the first teeth may not appear until as late as the tenth month. Usually, however, such delay can be attributed to bottle-feeding (with too small a teat), absence of sufficient hard food in the dietary after six months, and the presence of rickets. Mongolian idiots are also notorious for late dentition, the first teeth not appearing until the second year, a phenomenon also sometimes encountered in untreated cretins. In all instances in which the teeth appear late hard foods should be urged and concentrates of vitamins A and D should be administered in full doses according to the child's age.

Treatment

4.—ABNORMAL DENTITION

Mrs. Mellanby's work has suggested that vitamins A and D not only play a dominant part in ensuring well-constructed teeth, but may also determine that teeth are well placed, a point of importance in securing a good 'bite' and in preventing overcrowding with the attendant risk of the accumulation of food debris. Ectodermal dysplasia, characterized by grossly defective teeth, both in number and in structure, may be met with in association with defects of other ectodermal organs, such as the hair and skin (sweat glands). Severe gingivitis, as in Vincent's infection of the gums or in leukaemia, or severe scurvy, may lead to loosening of the teeth which may be shed prematurely; and a similar phenomenon is sometimes met with in 'pink' disease (infantile acrodynia, erythroedema polynuritis), in which passage of teeth in the stools has occasionally been an early sign of gross disorder. The characteristic notching of the upper central incisors of the permanent teeth seen in congenital syphilis (Hutchinson's teeth) is often associated with defects of the other teeth. A different type of impairment of the cutting edge of the corresponding teeth in the temporary set is sometimes seen in severe rickets (see Fig. 71) and should not be confused with the syphilitic variety.

Deficiency of vitamin D

Ectodermal dysplasia

Gingivitis

Pink disease

Congenital syphilis

Rickets

Yellow teeth which later become green have been described by Thursfield and Langmead in babies who were jaundiced at birth with persistence of the jaundice for many weeks or months. The coloration gradually fades. Pink teeth occur in that rare inborn error of metabolism, congenital porphyria.

Discoloration

5.—DISORDERS ASSOCIATED WITH DENTITION

When disorders occur in the teething period more trouble is likely to be seen with the cutting of the upper incisors than with that of the lower, and the molars frequently cause more disturbance than the

General disturbances

canines. Much depends upon the general state of the infant at the time, and dentition in general terms may be said to exaggerate certain propensities. Thus the restlessness, head-rolling, sleeplessness, and even convulsions, occurring at the end of the first year in an infant who is cutting teeth, may be clearly due to the presence of rickets, and such

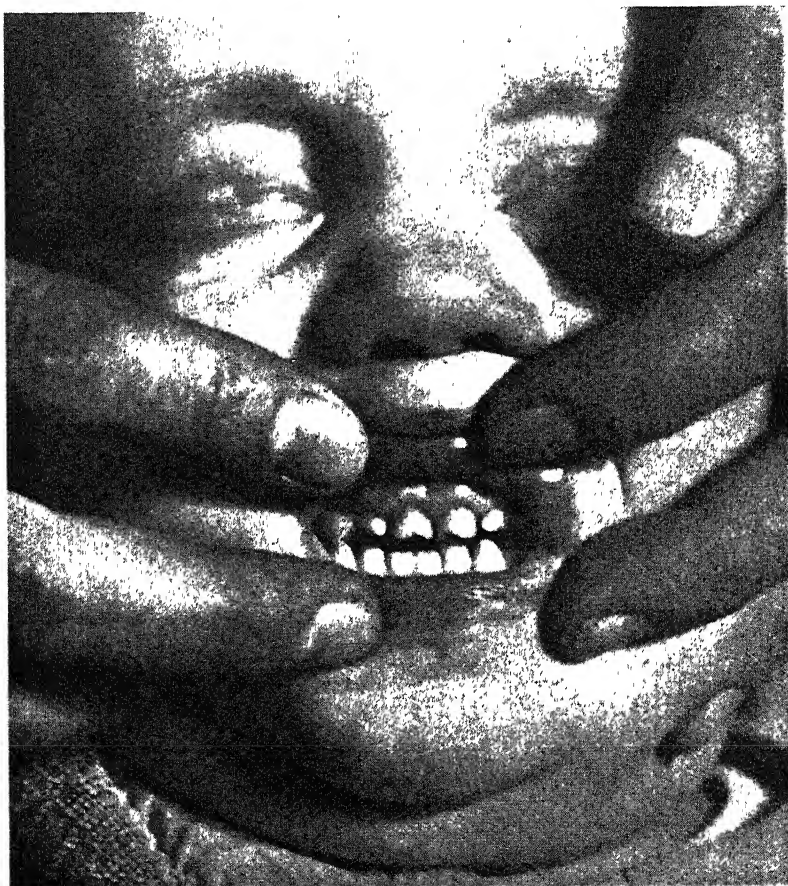


FIG. 71.—Notching of the primary teeth in rickets (boy with severe rickets aged 2 years and 5 months)

symptoms may yield more quickly and effectively to the administration of vitamin D in some concentrated form than to the usual sedatives.

*Stomatitis
and sequelae*

A certain amount of catarrhal stomatitis is almost a constant accompaniment of teething, and it is easy to understand how such an inflammatory condition of the mucous membrane of the mouth may spread by continuity in an otherwise unhealthy child, particularly in one whose diet is too rich in carbohydrate and defective in vitamin A and other protective substances. In this way may be explained the occurrence of pharyngitis (with an irritating cough), otitis media, bronchitis, and gastro-enteritis. With regard to the latter it must also be remembered

that the period of dentition corresponds to a time of almost experimental diet with daily changes and extensions.

A slowing of the previous steady increase in weight can also be explained by alimentary disturbances and the obvious reluctance to eat because of the pain thus caused. *Retardation of growth*

Skin disturbances are also not uncommon in association with dentition, and here again the teething process can be only one of several possible precipitating factors in such disorders as infantile eczema and lichen urticatus (papular urticaria or 'gum' rash); the dribbling and constant dampness are, however, responsible for the not infrequent dermatitis that appears, during teething, in the skin covering the chin and even the upper part of the chest. *Skin disturbances*

Popular tradition ascribes running of the eyes and some degree of photophobia to the cutting of the canines (or 'eye' teeth) but for this there seems little solid foundation. *Lacrimation and photophobia*

Whether or not fever can be caused by dentition is a debatable point. Obviously some of the inflammatory disturbances already mentioned may cause fever and this may be wrongly attributed to the teething process rather than, for example, to an otitis media. Further it is alleged that any febrile state will accelerate the appearance of teeth through the gums and thus the appearance of teeth after a bout of fever may be the result of the raised temperature instead of its cause. *Fever*

It follows that, before regarding dentition as the cause of any malady present in a young child in whom teething is occurring, a most careful examination must be made to exclude other disorders possibly precipitated or stirred up by the dentition process. If this were always done there would be less often seen the tragedy of a first diagnosis of 'teething' altered subsequently to tuberculous meningitis, a not infrequent occurrence in paediatric practice. *Differential diagnosis*

The various disorders mentioned above must receive the treatment described elsewhere under the appropriate headings. It remains to discuss the treatment of dentition as such. Lancing of the gums is still occasionally practised but rarely brings the expected relief and, in view of the observation that the pain may in some instances be due to tension over the periosteum rather than in the gum itself (see p. 604), is scarcely ever justified. Some relief can be obtained, as already mentioned, by supplying hard objects for chewing and local applications. *Treatment*

Sedative drugs should certainly be ordered for the restless child with sleepless nights, for clearly if this is not done by the medical practitioner the parents are extremely likely to employ some proprietary 'teething powder'. Chloral hydrate and bromides are most valuable in this connexion and the following is suitable for a child aged one year: *Lancing of gums*

Potassium bromide	—	—	—	—	2 grains
Chloral hydrate	—	—	—	—	2 grains
Glycerin	—	—	—	—	15 minims
Aniseed water	—	—	—	—	to 1 fl. drachm

Dose: One drachm every night as required. *Drugs*

DERMATITIS DUE TO INJURY AND POISONING INCLUDING FEIGNED ERUPTIONS

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Reference may also be made to the following titles:

ALLERGY DRUG ERUPTIONS
SKIN, OCCUPATIONAL DISEASES

1.-DEFINITION

*External
agents*

290.] This article deals with dermatoses caused by the exposure of the skin to noxious agencies of non-infective nature. It would therefore seem that 'feigned eruptions' may be reasonably included with them, since they differ only in the fact that the application is made intentionally instead of accidentally or in the course of the patient's occupation.

*Internal
agents*

It is also rational to include those eruptions which are caused by the absorption of chemical bodies otherwise than by the skin, such as those inhaled or ingested in the course of the patient's work. For a complete list of these the special articles on SKIN, OCCUPATIONAL DISEASES, and DRUG ERUPTIONS should be consulted, but an outline is given here of the classes to which they belong and a special description devoted to some few of importance.

2.-EXTERNALLY APPLIED AGENCIES: DIRECT EXPOSURE

(1)—Radio-Dermatitis

This includes the effects of exposure to heat, light, X-rays, and radium.

(a) Heat

The first of these is treated in the article on BURNS AND SCALDS, Vol. II, p. 719.

*(b) Light**Reactions
to mild
exposure*

Light, especially in strong sunlight and in ultra-violet rays, has an action very similar to that of X-rays and radium but almost invariably of milder degree. The immediate result of exposure to strong light is the production of redness within twenty-four hours. If the source of the rays is not very powerful or the exposure is of short duration, this redness subsides quickly and the skin returns to its former condition. When the action is more vigorous a slight branny desquamation occurs which is followed by an increase of the pigmentation. Repeated exposures call forth further pigmentation and, if the periods of exposure are not excessive, the skin becomes progressively darker until a deep brown colour is obtained which apparently protects the organ from further irritation.

*Reactions to
excessive
exposure*

If at any time the exposure is excessive, either in intensity or duration, there ensues a violent redness associated with oedema of the epidermis and papillary body, and sometimes also of the subcutaneous tissue. This is followed rapidly by the appearance of small or large vesicles in the epidermis, and the horny layer is subsequently shed in large sheets. Death of tissue sufficiently massive to produce ulceration is only rarely the result of visible or ultra-violet rays.

Should the exposure to these rays in heavy doses be repeated on many occasions, as occurs in people who work or play in countries where the sunlight is very powerful, there follows a train of disturbances to which Cheatele gave the name *biotripsis*. The first result is permanent dilatation of the small cutaneous vessels, occurring sometimes evenly over the exposed area and sometimes in patches. Following the telangiectases there develop patches of persistent pigment with some thinning of the skin and loss of the elastic tissue. The skin becomes deeply wrinkled, especially in parts such as the back of the neck where movement is free; this is the 'peasant neck' of Rasch and is nearly always present in elderly labourers working out of doors. In addition to this there appear patches of hyperkeratosis on the exposed parts and these may develop on the hands and forearms into a squamous-celled carcinoma, and on the face either into that form of new growth or into rodent ulcers.

(c) *X-rays and Radium*

In the case of exposure to the radiations from the X-ray tube or radium the results are similar in kind, but differ considerably in time of appearance and severity from those caused by light and ultra-violet rays.

The first difference lies in the latent period before the effect of exposure becomes obvious. Whereas after exposure to light and ultra-violet rays the effects are noticeable within twenty-four hours, with X-rays and radium there is a delay in the reactions varying from eight days to a fortnight in the case of X-rays, and longer in that of radium. The more intense and prolonged the exposure to these rays, the shorter is the period of latency before the appearance of symptoms. *Latent period*

The second difference lies in the greater severity of the early reaction to X- and radium rays. Whereas the early symptoms caused by light are limited to an inflammatory reaction of variable intensity, massive necroses with the production of ulceration result from gross over-exposure to the X- and radium rays. *Severity of reactions*

The first symptom caused by these is a dusky redness followed by intense vesication and loss of hair. Subsequently the whole of the epidermis and the papillary body undergo necrosis, producing an indolent and extremely painful ulcer which has apparently lost all tendency to heal and generally undergoes malignant transformation later.

Short of this intense disturbance, the effect may be limited to an erythema which is slow to disappear and may be accompanied by visible desquamation. In this case after the lapse of four to six weeks the skin may return to an apparently normal condition. This is, however, deceptive, since, after months or years, without any repetition of the exposure, degenerative changes take place.

Hair follicles, sweat glands, and sebaceous glands are lost permanently, telangiectases in tufted rather than linear form appear, the elastic tissue

is lost, and irregular keratinization gives rise to yellowish and rather crumbling warts. The ability of small wounds to heal is diminished, but not lost entirely, as is shown by the healing of these warts when treated with carbon dioxide snow.

It is most important to remember that a long series of moderate doses given with considerable intervals to the same area may produce these degenerative changes even to ulceration without at any time exciting the inflammatory erythema. It is therefore wise at the conclusion of a course of treatment by X-rays to hand the patient a chart showing the position, number, intensity, and sum total of the doses applied. Should further exposure be contemplated at any future time this chart should be consulted and the bygone treatment considered.

(d) Treatment of Radio-Dermatitis

Curiously enough, considering the great similarity between the symptoms of dermatitis due to light and ultra-violet rays and those due to X-rays and radium, the late symptoms due to the former may usually be treated successfully by the latter. The treatment should be applied with caution, limited to a total of two erythema doses, and given in such fractions that at no time is any visible reaction produced. Keratoses may be removed in both classes of case by the application of carbon dioxide snow in exposures varying in time from twenty to fifty seconds.

Ulcers should be excised and covered in with flaps or skin-grafts and when this is done the tissue removed should include the whole thickness of the subcutaneous tissue.

(2)—Dermatitis due wholly or mostly to Mechanical Irritation

Causes

This form is found chiefly as an occupational dermatitis and is due to repeated friction with sharp powders such as brick-dust, emery powder, carborundum, and metal filings. These give rise to a thickening of the horny layer, which may be healthy and merely protective, but in some cases is badly formed and is therefore liable to fissure. The mouths of the hair follicles share in the hyperkeratosis and the hair is crippled. From the interference with the free passage of the sebaceous secretion the health of the glands is upset and pustules may form round the hairs, especially those of the eyelashes, eyebrows, and bearded region of the face, thus determining the development of obstinate sycosis. This complication is seen with frequency in coal porters and may be therefore partly mechanical and partly toxic.

Plaster of Paris and Portland cement, which are both mechanical and chemical irritants, may set up the simple hyperkeratotic disturbance outlined above or, perhaps more frequently, an eczematous dermatitis.

(3)—Necrotic Dermatitis

Causes

This is due to the action of strongly active chemical bodies, such as mineral acids or caustic alkalis in high concentration, and some metallic salts such as potassium bichromate.

(4)—Toxic Dermatitis

This is due to the irritant effects of chemical bodies and differs from *Causes* the previous form in that it occurs only in living tissue whereas the necrotics will char or dissolve dead skin. Most of these are dealt with under the title SKIN, OCCUPATIONAL DISEASES, but those derived from plants may be mentioned.

It is almost true that most plants will irritate some individual and it is therefore impossible to give a complete list. The commonest are perhaps *Irritating plants* the following: Plants of the Rhus family, *R. toxicodendron*, *R. venenatum*, *R. diversiloba*, and *R. vernicifera*, the last being used by the Japanese for the production of lacquer. *Primula obconica*, much grown in England in greenhouses, is a plant to which a considerable proportion of people are susceptible, and Cranston Low proved that persons poisoned by this plant may develop a sensitiveness to other species of primula. Chrysanthemums, especially the large single variety known as *C. maximum*, are toxic to some people, and related to them are varieties of *Pyrethrum*. *Humea elegans*, a greenhouse climber, is well known to the horticulturist as a source of trouble, and the tomato plant frequently causes irritation in those who handle the hairy leaves in pinching out the side shoots. The spurges (*Euphorbia*) are irritant to many, but, as it is chiefly the juice of the plant that gives rise to irritation, dermatitis due to them is not particularly common.

Several woods, especially when reduced to fine powder, are notorious *Irritant woods* irritants, the chief being perhaps sandalwood and teak, but these come under the heading of occupational dermatitis since they are seldom operative except in the case of workers with them.

Mention should be made also of the somewhat recently described *Meadow dermatitis* eruption found in those who lie in meadows sun-bathing (meadow dermatitis). This appears usually in the form of an irritable erythema arranged in streaks on the body and limbs. The plant causing it is not known with certainty, and it may be due to the combination of the actions of a plant and sunlight. It has been observed in England but is apparently of more frequent occurrence in Central Europe.

Allied to this is the dermatosis known as 'berlocque dermatitis' or 'perfume dermatitis' (see also BRONZING OF THE SKIN, Vol. II, p. 713). *Berlocque dermatitis* Formerly commoner in Europe, it is now becoming progressively more frequent in England. It is due to the application to the skin of scents containing essential oils. Curiously enough it appears to be more often produced by expensive than by cheap perfumes. It is most frequently seen behind and below the ears and in the interclavicular hollow where women sometimes apply a touch of scent. It is more likely to occur if the scent is applied to the moist skin after a hot bath or if the patient applies it and is then exposed to strong sunlight. The name 'berlocque' is taken from the locket-like shape of the patches.

Sometimes there is first an acute erythema of the area followed by pigmentation, but not uncommonly the pigmentation is the first sign of

disturbance. Disfigurement is marked, as the patch develops a very dark colour which may persist for a long period after the last application. In a patient of mine the discoloration was still visible, though slight, four months after application. K. Touton gave the essential oils in the following order as regards their power to produce it: bergamot, cedar, lemon, lavender, neroli, limetta, rosemary. He stated that ethyl alcohol and brandy had some similar action and it would appear therefore that any soothing application should not contain alcohol.

Tar Before concluding this discussion of the chemical agencies producing toxic changes in the skin, a short outline may be given of those produced by the application of tar and its products. Tar is derived from two sources, wood and coal. Wood-tar consists mainly of guaiacol, pyrocatechol, and cresol, whereas the coal-tar contains more phenolic bodies, acridin, and anthracenes.

Wood-tar Wood-tar occasionally gives rise to hyperkeratosis of the hair follicles, forming comedo-like bodies at their openings, but prolonged search has failed to reveal to me any case of severe damage.

Coal-tar Coal-tar and its products are far more dangerous and appear to be more active if contact is made with the hot product. The first sign is a persistent red patch which soon becomes hyperkeratotic on the surface and infiltrated beneath. If the follicles are involved these grow up into small horns whereas the glabrous portion develops an apparently simple wart. After the formation of the follicular horns the overgrowth of horny and living epidermic cells extends to the bottom of the follicle, and where several of these are involved in a group a fleshy epithelial mass is formed to which the name 'tar molluscum' has been given.

Microscopically I cannot clearly distinguish them from a carcinoma, but clinically they are often extruded leaving a pit which heals to form a depressed scar. Sometimes, however, these growths become undoubtedly carcinomatous and form a slowly extending ulcer with deeply infiltrated and raised edges, the 'crateriform ulcer' of Hutchinson. Examined microscopically these crateriform ulcers are typical carcinomas, but are remarkable for the extensive zone of lymphoid infiltration surrounding them and forming a barrier between them and the healthy tissue beyond. Such ulcers often invade deeply and extend to the lymphatic glands as is the case with other cutaneous carcinomas, but, sometimes, if left alone and protected from further contact with tar, the whole growth may separate off from the surrounding tissue, slough out, and leave a clean punched-out ulcer which heals and forms a healthy scar. As it is impossible to foretell which growth will slough out and which will extend to the deeper tissues, they must all be excised.

The apparently simple warts of the glabrous portion may remain as such or die away in the absence of renewed contact with coal-tar products, or they may also increase in size and finally infiltrate the surrounding skin to form frank carcinomas. Modern investigation tends to incriminate the anthracene bodies as the most potent factors in the

production of tar cancer, but acridine is also an intense irritant of the skin. (See also CANCER, Vol. II, p. 740.)

As a link between those examples of dermatitis due to direct exposure of the skin to the agency in question and those in which the agent reaches the skin indirectly, reference may be made to the action of formaldehyde. Although it is well known that formaldehyde, whether acting as a vapour or in solution, is a violent irritant to the skin, it is perhaps not universally realized that in a sensitive patient who has already suffered from formaldehyde dermatitis the compound may affect the skin without direct exposure. Many years ago patients who had recently suffered from formaldehyde dermatitis were given small doses of formaldehyde in milk with the immediate result of a fresh outbreak. A pathologist who had suffered severely from formaldehyde dermatitis found that even when his hands were closely covered with surgical rubber gloves a few inhalations of the formaldehyde-laden air of a laboratory determined itching and pain in his hands, although none of the compound could reach them directly. *Formaldehyde*

3.—INTERNALLY ABSORBED AGENCIES: INDIRECT EXPOSURE

(1)—Drug Eruptions

These are discussed in the article DRUG ERUPTIONS, but there is one, namely arsenic, which appears to merit mention here.

(2)—Arsenic

This element may be absorbed accidentally quite apart from its use as a drug. It has given rise to widespread poisoning when present as an impurity in the sulphuric acid used in the manufacture of glucose for the production of beer. It has given rise also to sporadic cases of poisoning when compounds containing it have been used to colour materials, for example wall-papers. It was and still is used widely as arsenate of lead in sprays to protect fruit trees from the attack of caterpillars. In this form it has caused poisoning in two ways—namely, poisoning of the man applying the spray by inhalation of the mist, and poisoning of the consumer of the fruit contaminated with arsenic. In addition it has of course been used many times as an intentional poison by criminals. *Sources of arsenic*

Arsenic may affect the skin either acutely from the administration of large doses or chronically from the long-continued absorption of small doses. In the former event the position is complicated by the toxic action of the drug on the liver and kidneys, and it is not known precisely what part of the cutaneous symptoms is due to the action of arsenic on the skin and what to the hepatic damage. The acute form is discussed in the article on DRUG ERUPTIONS, and only that due to the chronic absorption of small doses will be discussed here. XIV. 409.

*Chronic
arsenic
poisoning*

The cutaneous symptoms arising from prolonged absorption of arsenic may take several forms.

(a) Erythemato-Squamous Form

*Diagnosis
from
psoriasis*

In some people inhalation or ingestion of the drug is followed, after an interval of a few months, by an eruption of red discs which are slightly swollen and infiltrated, showing adherent, whitish scales on the surface, and affecting chiefly the elbows, knees, and extensor surfaces of the limbs. This eruption may develop also on the face. On the limbs it may be confused with psoriasis, and indeed the differential diagnosis is not easy. The points which may help are: (i) there is no history of a previous attack; (ii) patches do not appear and disappear, but there is a slow increase in number; (iii) when the skin is picked up a much more definite thickening is felt than is the case with psoriasis; (iv) the scales are not so silvery and, on removal and scraping of the underlying surface, the punctate haemorrhage of psoriasis is not found.

*From lupus
erythematosus*

On the face the eruption may be mistaken for lupus erythematosus, but the horny plugs giving an appearance resembling pumice stone are not present in the arsenical eruption. Lastly there can sometimes be found on the palms corroborative evidence in the form of a peculiar persistent flush of the skin on the palmar aspect over the fifth metacarpal bone.

(b) Arsenical Pigmentation

*Distribution
of pigment*

This affects chiefly the trunk and neck but appears also all over the skin. It affects wide areas without any sharp margin, is of a dark colour, and is beset with small non-pigmented areas about a quarter of an inch in diameter, hence the name 'raindrop' pigmentation. This irregularity is often very pronounced on the neck and has given rise to the expression 'arsenical dirty neck' (see BRONZING OF THE SKIN, Vol. II, p. 712).

(c) Arsenical Hyperkeratosis

This is usually a very late and quite persistent symptom. The palms and soles show small keratoses about one-sixteenth of an inch in diameter, for the most part situated at the openings of the sweat glands. Sometimes there is a history of preceding hyperidrosis of these regions. In addition to the bead-like hyperkeratoses diffuse hyperkeratosis may also be present.

Whether this form ever dies out is doubtful, for I have seen it persist for twenty years after the completion of a long course of arsenic given out medically. On very rare occasions malignant transformation may excise it.

The app also some doubt whether in cases of psoriasis treated with such or repeated courses of arsenic a malignant change in one or products, or psoriatic patches is not the result of the drug. surrounding skin to incriminate the

4.—'FEIGNED ERUPTIONS' SOMETIMES CALLED 'DERMATITIS ARTEFACTA'

These are produced by children as a joke, sometimes in veritable epidemics owing to the tendency of children to imitate one another, by hysterical individuals, usually of the female sex, and rationally by both sexes in order to incapacitate themselves for some distasteful duty.

The chief form found in children is that known to them as 'tiger bites'. It is produced by sucking a portion of the skin and sometimes pinching it between the front teeth until it becomes oedematous. The wheal thus produced is then rubbed with the moistened finger until the sodden horny layer is removed leaving a weeping abrasion beneath. One or many may be present according to the dramatic enthusiasm of the actor. In the hysterical cases this method is often used; but in addition a traumatic dermatitis may be produced by painting areas of the skin with strong acids, usually hydrochloric or crude carbolic, or with a preparation of cantharides.

In ordinary right-handed persons the eruption usually predominates on the left side of the body and in front; but in some recorded cases almost all parts of the back, even those reached with difficulty, have been affected. In some of the patients dissociation has been noted and the patient is genuinely unaware that she is responsible for the eruption.

The diagnosis lies in the peculiar shape and distribution of the patches, *Diagnosis* unlike that of any true skin disease; but certain tests may be applied. In a suspected case a limb should be covered with a sealed dressing such as glycerin-zinc oxide-gelatine paste, when the eruption will of course disappear though it may come out in other places. When phenol compounds have been used the patch will smell for days after the application, and if hydrochloric acid has been applied a piece of moistened blue litmus paper will turn sharply red for a surprisingly long time. I am not aware of any simple test as evidence of cantharides, but occasionally a history can be elicited of some painful condition, such as pleurodynia, that has been treated medically by blistering and has thus suggested the method to the patient. The treatment of this class of case should be referred to the psychologist.

Lastly there are the rational cases. A considerable number of these were seen in London during the War and generally took the form of a pustular dermatitis on the chest and back designed to render the wearing of a military pack impossible. I suspected a croton oil liniment as the agency used but was unable to prove it.

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DERMATITIS, EXFOLIATIVE

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Reference may also be made to the following titles:

ALLERGY

ERYTHEMA

1.—DEFINITION

291.] Exfoliative dermatitis, or pityriasis rubra, represents an unusual disturbance of the epidermis and true skin in which a generalized erythema is accompanied by a persistent and intractable desquamation, with irritation, superficial distress, and exhaustion. The sufferer becomes excessively sensitive to external changes of temperature, to pressure and friction, and the skin becomes harsh and loses its normal elasticity. Fissuring and secondary infection occur and in many cases atrophy follows. Nails and hair may fall out when the disturbance is unusually severe. The termination depends in part on the age and physical reserve of the sufferer, and in part on the removal of the aetiological factor, when this can be discovered.

2.—AETIOLOGY

Exfoliative dermatitis should probably be regarded not so much as a single disease of a constant aetiology, as a group of conditions of similar symptomatology in which a number of causes induce outbreaks.

A rational, but perhaps not universally accepted, interpretation of exfoliative dermatitis is that it represents an irritative dermatitis in which the causal factor may be either endogenous or exogenous. Many such factors are recognized and it is probable that further research will reveal hitherto unknown provocative agents which determine disturbances in the group at present classified as 'idiopathic'.

*Classification
of causes*

The aetiological factors, recognized from clinical experience, may conveniently be divided as follows: (1) external irritants, physical and chemical; (2) internally absorbed irritants, chemical or bacterial; (3) abnormal activity of the haemopoietic system. There exists also a so-called idiopathic group, which includes those cases in which a recognized aetiological factor cannot be determined; and a group, possibly included on insufficient grounds, in which an external infective factor is responsible. With the exception of the last-mentioned group, exfoliative dermatitis appears to occur almost entirely in persons over the age of 30 and is rather more common in males than in females. Some authors suggest an underlying tuberculous, rheumatic, or gouty diathesis, but it seems that the eruption may occur in persons of general good health and physique who have not shown any antecedent signs of local or general abnormality.

Chrysarobin

External irritants. One of the commonest external irritants responsible for the production of exfoliative dermatitis is chrysarobin. This substance is universally used in the treatment of psoriasis and its value lies in the intense erythema which follows its external application; in fact, unless it produces such erythema, it has little effect on psoriasis. In rare cases its prolonged application initiates an outbreak of generalized exfoliation which continues for many weeks after the use of chrysarobin has been suspended. It is possible that the outbreak represents some inherent abnormality in the sufferer's skin rather than any intense reaction to the chemical agent. Against this conception, however, it should be pointed out that some persons will develop a widespread erythema with persistent exfoliation after contact of the skin with even the weakest dilutions of normally innocuous substances, such as the mercurials and iodoform. Such persons should be regarded as 'allergized' to an antigen ('metal-cum-protein') resulting from the combination of the metal with the skin.

Sunlight

Cases of persistent, and sometimes fatal, exfoliative dermatitis may follow the exposure of the skin to sunlight. The normal response of human skin to over-exposure to solar radiation consists of an almost immediate erythema and oedema. This subsides after a few days and is followed by exfoliation of short duration. In rare instances, however, the erythema and exfoliation persist for many weeks, and, if the 'shock' resulting is sufficiently violent, death from exhaustion may occur. It is probable that in such cases an unsuspected abnormality was present in the skin before exposure to the irritant took place.

Such a predisposition to exfoliation might explain in some degree those cases of exfoliative dermatitis which follow the prolonged treat-

ment of eczema. In rare cases, patients with this condition are intolerant of the simplest forms of external medication, and they gradually develop an intractable and generalized 'peeling' of the skin which cannot be checked. *Intolerance to external medication*

Internal irritants. Acute generalized urticaria, followed by an almost immediate severe and persistent exfoliation, sometimes occurs as a result of the administration of the organic compounds of arsenic which are employed in the treatment of syphilis. These complications are rare, rather less than 1 per cent of individuals being affected; and of these less than 10 per cent end fatally as a result of the dermatitis. This intolerance to arsenicals may follow even the smallest dose and be independent of the type of preparation and its mode of administration; furthermore, a matter of great importance, it appears to be permanent. After one attack of exfoliation the individual remains intolerant for years to similar injections. Such 'metallic' intolerance is also found among a small proportion of persons treated with gold compounds. *To organic arsenic compounds*
To gold compounds

These patients show a similar cutaneous reaction and, as in arsenical dermatitis, may develop a toxic nephritis. It follows that in all cases undergoing arsenic and gold therapy, inquiry must be made about the possible occurrence of irritation of the skin following any dose, such irritation completely contra-indicating further therapy of the same type for many months, if not for ever.

Toxaemia. A bacterial toxaemia may engender single or recurrent attacks of generalized erythema followed in a few days by exfoliation. A classical, but rarely recognized, example of toxic exfoliative dermatitis is scarlatina. In this condition the human skin, possibly as a result of sensitization or perhaps as the result of development of antibodies in its own tissue, shows a transient but intense congestion followed by exfoliation. The recurrent attacks of peeling found in the eruption known as erythema scarlatiniforme and possibly due to the deposition of the streptococcus itself or the circulation of its toxin in the skin may be an analogous condition. In this the exfoliation, though severe, is temporary and followed by months or years of immunity. *Scarlatina*
Erythema scarlatini-forme

Disorders of the Haemopoietic System. Cases of Hodgkin's disease and lymphoid leukaemia may present a clinical picture of exfoliative dermatitis. Generalized lymphosarcomatosis and mycosis fungoides may be similarly accompanied by persistent and widespread erythema, exfoliation, and irritation.

3.—MORBID ANATOMY AND HISTOLOGY

The pathology, like the aetiology of exfoliative dermatitis, is inconstant, but certain characteristics are common to all cases. Variations depend on the duration and on the rapidity of onset of the outbreak. The lesions include thickening of the epidermis, irregular cornification, and inflammatory exudation into all areas of the skin, combined with

widespread epithelial degenerative changes. Secondary anaemia and eosinophilia accompany the eruption, and in a small proportion a lymphocytosis is also present. The chronic cases show a partial or complete obliteration of the glandular elements of the skin.

The fasting blood-sugar may be raised and it has been stated that the urine shows a reduced excretion of nitrogen but an increase of uric acid. The total quantity of urine is diminished, probably on account of the increased superficial loss from the skin.

4.—CLINICAL PICTURE

Onset

The onset of the disease may be gradual or sudden. The earliest visible changes are erythema and slight oedema of the skin. Pressure on the

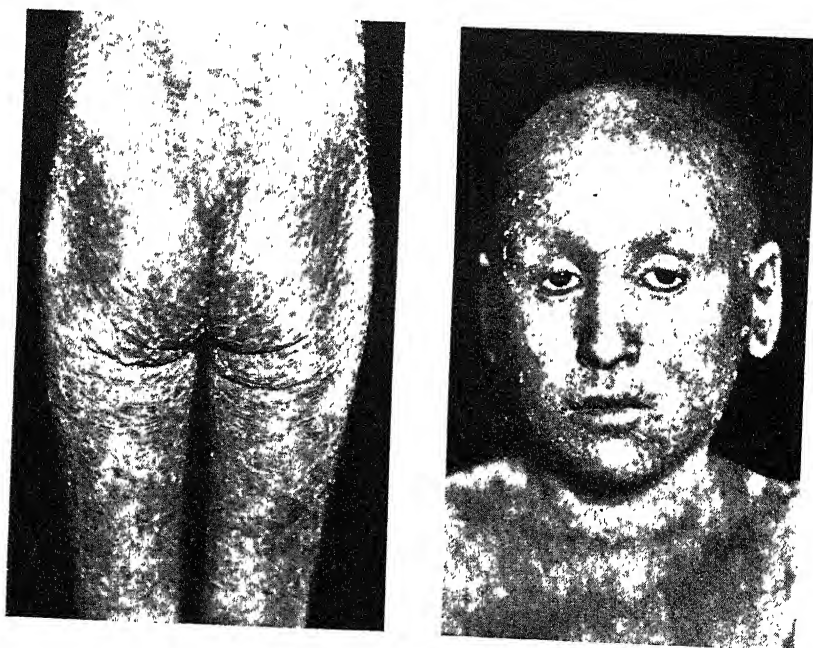


FIG. 72.—Exfoliative dermatitis

Eruption

skin with the finger-tip reveals a dilatation of the entire superficial vascular system with only the most transient pallor. After a few days, close inspection shows a fine and branny desquamation. The skin temperature is raised. The eruption may begin over a widespread area or may be limited at first to the antecubital, axillary, and genitocrural flexures. In the majority of cases the eruption spreads in the course of a few days to the rest of the integument (see Fig. 72). Although cases of localized exfoliative dermatitis have been reported, it is doubtful if they should be regarded as belonging to the group of eruptions now under discussion.

The patient complains of general 'tenderness' of the skin with pruritus, *Symptoms* usually moderate but occasionally severe. Temperature changes in the surrounding atmosphere exaggerate the discomfort and the sufferer cannot tolerate either cool or moving air because of the excessive loss of body heat through radiation from dilated superficial blood-vessels.

The Idiopathic Group. This group includes those cases in which only a vague conjecture can be made as to the possible causes. From time to time exfoliative dermatitis of an insidious onset appears in otherwise healthy persons in whom neither external nor internal irritants appear to be present. Histological examination of the lymphatic glands, X-ray investigation, palpation of the liver and spleen, and total and differential white cell counts do not show any departure from the normal, and there is not any evidence of endocrine dysfunction.

Epidemic Exfoliative Dermatitis. In the latter part of the last century, and on various occasions since, an epidemic eruption with constitutional disturbances has been noticed. An irregular and patchy erythema accompanied by transient vesiculation and often lymphatic enlargement, gastro-intestinal upset, and conjunctivitis has attacked a number of individuals simultaneously. Such an outbreak gradually subsides within three months, but a proportion of deaths varying between 10 and 20 per cent makes the prognosis uncertain. Hair and nails may fall off. This disease, commonly referred to as 'epidemic exfoliative dermatitis', is probably due to an external infection, accompanied by a severe toxæmia, the causal organisms belonging to the staphylococcal group. The so-called 'Marylebone epidemic', however, was traced by Copeman to the presence of formaldehyde in the milk, and was not an infection.

Ritter's Disease. A somewhat similar disease occurs in infants, and is usually termed 'Ritter's disease'. This is found in children of under three months of age and is generally regarded as a severe form of pemphigus neonatorum. Pemphigus neonatorum is impetigo contagiosa, a streptococcal infection of a delicate infantile skin lacking in resistance producing profound shock and general toxæmia. The prognosis, on account of these complications, is very grave. About 50 per cent of cases prove fatal.

5.—COURSE AND PROGNOSIS

The course of exfoliative dermatitis is usually afebrile, but the temperature is raised in cases with a sudden onset. In these latter, in which incidentally the prognosis is more hopeful, the disease runs a course of some weeks and gradually disappears. In other cases remissions of varying duration occur but complete recovery is not established. It is in this last group that atrophy of the skin occurs, the eventual clinical picture being that of a somewhat emaciated individual covered with a dry scaling skin which appears to have lost all its elasticity and has the aspect of tissue paper. *Course*

Recurrences of acute, as distinguished from chronic, exfoliation may

occur for many years, particularly when the individual is re-exposed to a recognized chemical or bacterial toxæmia.

The scales have a thin dirty-gray appearance and in severe cases may be produced in enormous amounts. The entire bed and floor may be almost covered for indefinite periods with these somewhat greasy particles.

Occasionally the underlying skin may show serous exudation with a gummy glazed look; such exudation is found only in sufferers in whom pruritus is well-marked. It may result from the rubbing which the patient gives his skin in trying to find relief from his intolerable discomfort.

Voluntary movement eventually becomes difficult because of the onset of stiffening of the skin around the joints. Secondary infection produces furunculosis; cachexia and exhaustion lower the resistance of the individual still further. Pigmentation is common in the more chronic cases, and in patients who recover it frequently persists for many months after the disappearance of the eruption.

Prognosis

The prognosis depends essentially on two factors: the general health and resistance of the patient, and the transient or permanent presence of the aetiological factor. The very young, the very old, or patients debilitated by years of widespread eczema or psoriasis, are more likely to succumb to exhaustion consequent upon broken nights and physical discomfort than is the patient in whom the cause lies in susceptibility to arsenobenzene compounds. The latter can eliminate his irritant toxin rapidly, the former cannot.

6.—DIFFERENTIAL DIAGNOSIS

It is impossible, at a first inspection, in any given case of generalized erythema accompanied by pruritus, burning, and exfoliation, to state dogmatically that the eruption is not that of exfoliative dermatitis. Clinical experience shows that the latter disease may follow on almost any widespread persistent erythema. Exfoliative dermatitis has followed eruptions of such diverse aetiology as lichen planus, psoriasis, eczema, sulphur dermatitis, and even sunburn. A few days of observation, however, will usually serve to determine the diagnosis. A transient exfoliation due to external irritation will subside very rapidly and will remain confined to the areas exposed.

Xerodermia or ichthyosis dates from infancy and is not accompanied by erythema or by exudation or irritation.

7.—TREATMENT

In the absence of a known chemical or bacterial toxin, the treatment must be confined to local palliative measures and to the support of the

general health of the individual. When a metallic toxæmia is present the administration of sodium thiosulphate intravenously and of glucose by the mouth appears to be of value. In the presence of an external infective factor, as in Ritter's disease or epidemic exfoliative dermatitis, the application of mercurials in weak dilutions or antiseptics, such as acriflavine or gentian violet in dilutions of 1 in 1,000, is of value. When serous exudation and raised temperature are present mercurials are contra-indicated since the risk of mercurialism is then by no means negligible.

In the majority of other cases it is doubtful if any form of treatment is more than palliative. The eruption will follow its course and remains uninfluenced provided the external treatment is in no way stimulating. Bland applications of mild astringent capacity are helpful. Soft paraffin and lanolin with 0.5 per cent of menthol, camphor, or phenol, ease the pruritus and appear to lessen the undue radiation of heat. Lotions containing olive oil, linseed oil, liquid paraffin, and almond oil, applied to the skin with gauze bandages, give local relief and should be changed not more than twice during the twenty-four hours. Frequently gauze bandages impregnated with gelatin and ichthammol (ichtiopaste), changed once a week, bring about improvement. The free application of a simple non-medicated dusting powder (e.g. sterilized French chalk) will often give great ease. The skin may be cleansed with cold cream or olive oil but energetic removal of scales must be avoided. Oatmeal and bran baths are sometimes soothing, but must be followed by the application of bland and oily medicaments. Internally, quinine, arsenic, salicylates, and antimony are empirically administered. In cases in which there is a considerable loss of sodium chloride in the sweat, the exuded serum, or the desquamated epithelial cells, salt in large doses by the mouth or by intravenous injection will occasionally bring about dramatic improvement.

*Palliative
measures*

Attention should also be directed to the patient's general health. The diet should be liberal but not of a type that may induce gastric irritation. Alcohol, except as a stimulant in exhaustion, should be avoided. Bland fluids may be freely given. The bowels must be kept very regular since loss of moisture by the skin may be compensated by a withdrawal of fluid from the large intestine. The excessive loss of heat which results from the widespread superficial vascular dilatation renders the subject liable to pulmonary complications and to shock; the room should therefore be warm and free from draughts. Bedding should be light, and persistent pressure avoided on account of the liability to develop bed-sores. Underclothing should preferably be of an open-weave cotton, which can be cleansed easily and produces very little friction. Sleeplessness is best combated by barbiturates; bromides should be avoided because of their tendency to encourage superficial staphylococcal infection; and aspirin should be avoided because it may induce hyperidrosis and consequent increase of local distress.

*General
treatment*

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DERMATITIS HERPETIFORMIS

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Reference may also be made to the following titles:

ALLERGY

IMPETIGO

ERYTHEMA

PEMPHIGUS

1.—DEFINITION

292.] Dermatitis herpetiformis (Duhring's disease, impetigo herpetiformis) is a rare eruption of uncertain aetiology. It is characterized by the appearance of grouped vesicles associated with intense irritation. The condition is chronic and recurrent, probably forming a link in the chain uniting urticaria at the one end with pemphigus at the other.

2.—AETIOLOGY

It is probable that the eruption represents a manifestation of local intolerance to endogenous irritants. As in many other skin eruptions of varying morphology, progress, and distribution, dermatitis herpetiformis should not be regarded as a single disease with a constant aetiological factor but, as mentioned above, rather as a link in a series of skin disturbances to which further investigation may possibly add some of the erythemas such as erythema multiforme and erythema nodosum.

Allergic factors

That dermatitis herpetiformis is related to the allergic disturbances is well exemplified by its reaction to internal or external administration of bromides and iodides. Given by the mouth these salts almost invariably cause not only an increased efflorescence of vesicles, but also an increase in the irritation. Painting of the skin with these substances, or injection of them, induces in the great majority of cases a violent local response. A similar excessive response follows application of many bacterial vaccines or even insect stings.

In any given case it appears that a number of factors are simultaneously pathogenic, and such a conception would account for the many cases cited in the literature in which there was a favourable response to the removal of diverse chemical irritants or toxic foci. The pathogeny lies rather in an individual peculiarity of response rather than in a common response to a common factor.

Gastro-intestinal toxæmia seems to be responsible in a proportion of cases, in that it may provide a focus of persistent septic absorption with consequent sensitization.

Cases have been reported in which the eruption has appeared for the first time after vaccination.

Psychic factors

Since dermatitis herpetiformis must thus be logically included in the allergic disturbances, it is not surprising to find psychic factors among the exciting influences. Nervous strain or emotional shock may precipitate outbreaks.

Tuberculosis, of human and bovine type, has been cited as a cause, but it is probable that such toxæmia is merely a coincidental source of allergen and that tuberculin sensitization is no more a constant factor than is sensitization to staphylococcal or streptococcal toxins.

3.—MORBID ANATOMY

The pathology is that of a localized serous effusion in the papillary layer of the corium. Should this become well-marked, as it does in the majority of cases, the epidermis is secondarily involved and a vesicle is produced. The vesicle may be formed either between the papillary body and the epidermis, lifting the latter in its entirety to form the roof, or may occasionally develop between the mucous or horny layers, in which case the roof consists of the horny layer alone. A localized and a generalized eosinophilia (7 to 20 per cent) is usual. This latter change, at one time considered diagnostic of dermatitis herpetiformis, is probably present in the majority of pemphigoid eruptions of central origin.

Bacteriology

The purulent nature of the lesions is due to a superimposed staphylococcal infection from skin-borne organisms and is not due to a bacteraemia. Blood cultures are sterile and transfusions from sufferers into animals fail to reproduce the disturbance.

4.—CLINICAL PICTURE

Dermatitis herpetiformis may have an acute or a gradual onset. A *Onset* proportion of patients complain of a malaise such as normally precedes the exanthemata, loss of appetite, and gastro-intestinal disturbance; these symptoms, with occasionally a slight rise of temperature, are accompanied by widespread pruritus in a skin which, at the time, is macroscopically normal. Within a day or two areas of irregular erythema of an urticarial appearance are visible, and these rapidly become papular and vesicular. Secondary infection renders the vesicles pustular. Friction and scratching rupture the blebs with the result that the skin shows

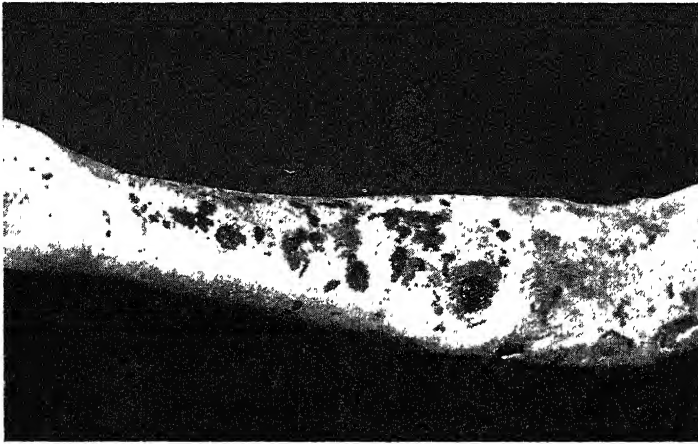


FIG. 73.—Dermatitis herpetiformis (haemorrhagic type)

multiple raw areas denuded of epithelium. As the disease progresses, further outbreaks occur and lesions pass through the above stages in regular sequence. As fresh crops appear the preceding blebs tend to heal spontaneously, leaving, however, a prolonged pigmentation (see Fig. 73).

After the first manifestation of the disease subsequent progress is extremely variable; occasionally the eruption clears up rapidly, and months or years may elapse before a further attack occurs. Usually, however, there is a continual appearance of fresh groups of vesicles, and long periods of continuous distress ensue before remission occurs.

The lesions do not always progress through the above-mentioned stages. Erythematous papules may remain as such without showing vesiculation, and spontaneous resolution occurs. In the severe cases the vesicles may contain traces of blood, but a generalized purpuric tendency is extremely rare.

Grouping of the lesions is characteristic, some half-dozen or more *Distribution of lesions* vesicles or papules appearing simultaneously in close proximity. Such

groups are found particularly around the shoulder, elbow, lumbar regions, and knee. The number of groups present simultaneously is variable. In mild cases, or in the periods of remission experienced by the severe cases, only very few patches are found. In the most violent cases almost the entire integument may be involved.

*Appearance
of blisters*

The shape and appearance of individual blisters are unusual and serve to differentiate the eruption from other bullous diseases. Instead of being circular in outline, as in the latter, they are frequently angular or stellate, with a prolongation of the bleb running out sharply to the neighbouring and unaffected skin. Occasionally even semicircular or crescentic lesions are found. The fully developed bulla may be either tense and distended, or quite flaccid; blebs in close proximity may become confluent and the resultant bulla may be several inches in size.

*Involvement
of mucous
membranes*

In the more violent cases the mucous membranes, e.g. the conjunctivae, lips, mouth, and larynx may be involved.

Irritation

Itching is almost constant and at times appears to be independent of the degree of visible disturbance. Rupture of the vesicles by the consequent scratching does not induce local comfort, the skin becoming simultaneously hyperaesthetic. Movement tends to be impaired from involvement of the skin surrounding the joints. Friction of clothing on the denuded areas gives rise to considerable discomfort, the serous discharge causing adhesion of dressings and clothing to the skin.

*General
condition*

Appetite generally remains good although mastication and swallowing may be interfered with by the presence of lesions in mouth or throat. Sleep is broken and difficult to obtain because of the pruritus and discomfort; indeed, the patient becomes a misery alike to himself and others.

*Intercurrent
disease*

Intercurrent disease is not usual except in such outbreaks as are accompanied by involvement of the trachea or possibly bronchi. A septic broncho-pneumonia may prove a terminal event.

5.—PROGNOSIS

The prognosis as regards danger to life is favourable—in fact one of the diagnostic features of the disease is that the sufferer maintains good general health and physique for long periods; but it is impossible to foretell how long the recurrent attacks of eruption will continue. Both the severity and the duration of attacks tend to become less marked with increase in age, and, provided intercurrent complications do not occur, the sufferer will often show an amelioration of symptoms, both subjective and objective. In a small proportion of cases permanent relief occurs.

Should attacks occur for the first time in weak or debilitated persons, then pulmonary disease occurring as a result of the involvement of the mucous membranes of the mouth and the respiratory tract may induce a fatal end; on the other hand, such pyogenic disturbances

occurring in the young or middle-aged may induce a non-specific desensitization with permanent freedom.

Some writers claim, with authenticated examples, that dermatitis herpetiformis may eventually 'degenerate' into the next 'link of the chain', pemphigus chronicus. In this condition the lesions become more extensive and more frequent with a consequent increased physical and mental exhaustion, two features which, by lowering the general health of sufferer, bring about death.

6.—DIFFERENTIAL DIAGNOSIS

It is frequently difficult, and perhaps illogical, in certain cases to draw a line of demarcation between pemphigus and dermatitis herpetiformis. In a typical example of the former, however, the lesions are large and do not show any tendency to grouping. They arise from apparently normal skin without erythema, and irritation is not a prominent symptom. In erythema multiforme the history given is often rather that of recurrent attacks lasting for 10 to 14 days over a number of years with long periods of complete immunity. The distribution is localized in the majority of cases to the hands, forearms, neck, and mouth, the lesions healing spontaneously without pigmentation. In this eruption there is not the intense irritation of dermatitis herpetiformis but merely a soreness in the skin denuded of its epithelium.

*Diagnosis
from
pemphigus*

*From
erythema
multiforme*

The lesions in urticaria may occasionally be modified in their appearance by showing vesiculation. Such vesicles, however, are found in a small proportion only of the wheals and arise from the centre of urticarial papules without replacing them.

*From
urticaria*

The barbiturates, bromides, iodides, and phenolphthalein appear at times to produce a widespread vesicular eruption. Such a response must be differentiated from an exacerbation of dermatitis herpetiformis resulting from administration of these substances. A drug eruption of an acute type follows immediately after the ingestion of the causal chemical; the lesions are uniform and do not show the angular vesiculation of the disease under discussion. They clear spontaneously and are rarely associated with intense irritation.

*From drug
eruptions*

Herpes gestationis—a generalized bullous eruption—possibly represents a particular type of dermatitis herpetiformis. The disturbance, as its name implies, occurs only during pregnancy, and clears up on its termination. The eruption will, however, probably reappear during subsequent pregnancies.

*From herpes
gestationis*

Impetigo (in the new-born termed pemphigus neonatorum) is due to a superficial streptococcal infection of the skin. The lesions begin as pin-point blisters and increase rapidly in size; unless they are treated, the peripheral increase and multiplicity of lesions continues indefinitely. There are no subjective symptoms, and the spread is due solely to auto-inoculation. Others in immediate contact become infe

*From
impetigo*

Under external antiseptics rapid improvement occurs. Microscopical examination of an unbroken and early bulla shows a streptococcal invasion. There is no irritation in impetigo, in contrast with dermatitis herpetiformis.

7.—TREATMENT

In considering the treatment of dermatitis herpetiformis attention must be devoted to three main considerations: (a) eradication of possible aetiological elements; (b) empirical interference with the morbid process itself; and (c) local care to provide relief from symptoms. Accepting septic absorption as a possible aggravating, if not the responsible, factor, eradication of toxic foci in the teeth, tonsils, accessory sinuses, ear, lung, or alimentary canal must be undertaken. A disturbance of chemical equilibrium has admittedly a part in the development of lesions and for this reason attention must be devoted to the functional efficiency of the stomach, intestine, and kidneys. Diet should be full and nutritious, and the vitamin intake requires particular attention. Saline purges are preferable to other intestinal stimulants. Internal antiseptics appear to be of doubtful value. Consideration must be given to possible abnormalities in the thyroid and pancreatic secretions as evidenced by the basal metabolic rate and blood-sugar curve estimations. Opiates are indicated in patients suffering from the effects of exhaustion and disturbed sleep induced by irritation.

Arsenic

The value of certain empirical remedies is unquestionable. Above all others arsenic is outstanding in its frequent and almost dramatic effects. It may be administered as Fowler's solution in doses of 2 minims as a tonic, or larger doses, e.g. 6 minims increased to the limit of tolerance, may be given. In many cases the response to such large doses is very rapid. Signs of intolerance are shown by nausea, dryness and irritation of the hands, conjunctivitis, and rarely diarrhoea. Patients will often state dogmatically that relief does not occur until one or more of these symptoms have become manifest; nevertheless a small reduction of dosage may be made without risk of relapse. If continued medication is decided upon, regular observation for palmar and plantar hyperkeratosis and for general exfoliation must be maintained. Arsenic may be administered intravenously by giving in small doses any of the various antisiphilitic preparations, e.g. stabilarsan, 0.3 gram weekly.

Quinine and strychnine

Quinine and strychnine, by some incompletely understood mechanism, are occasionally of great value, and they may wisely be administered during the intervals of treatment with arsenic when this has temporarily to be withdrawn. For this purpose pills containing quinine sulphate $\frac{1}{2}$ grain with extract of nux vomica $\frac{1}{10}$ grain are suitable.

Calcium gluconate or levulinate by intravenous or intramuscular injection is worthy of trial.

Whole-blood injections (3 to 10 c.c.) at weekly intervals over periods of three months will sometimes produce a non-specific desensitization, as will also injections of peptone or sterile milk. Blood transfusions have been reported as being successfully employed in cases in which the eruption is very severe and in which physical exhaustion is well marked.

External treatment is largely confined to the use of astringents, antiseptics, and anti-pruritics. These may be applied as lotions, ointments, or powders, for example:

Solution of coal tar	-	-	-	-	120 minims
Strong solution of lead subacetate	-	-	-	-	180 minims
Zinc oxide	-	-	-	-	240 grains
Starch	-	-	-	-	240 grains
Glycerin	-	-	-	-	120 minims
Water	-	-	-	-	to 20 fl. ounces
Phenol	-	-	-	-	7 grains
Glycerin of lead subacetate	-	-	-	-	60 minims
Yellow soft paraffin	-	-	-	-	540 grains
Percaine	-	-	-	-	3 grains
Zinc oxide	-	-	-	-	120 grains
Boric acid	-	-	-	-	120 grains
Starch	-	-	-	-	240 grains
Ichthammol	-	-	-	-	20 grains
Alcohol, 90 per cent	-	-	-	-	10 minims
Rose water	-	-	-	-	to 1 fl. ounce

Cold creams, zinc oxide pastes, or even applications of plain soft paraffin spread on gauze or non-medicated lint and bandaged onto the vesicular areas, frequently give temporary relief.

Camphor	-	-	-	-	6 grains
Cold cream	-	-	-	-	to 1 ounce
Ichthammol	-	-	-	-	30 grains
Zinc oxide	-	-	-	-	120 grains
Starch	-	-	-	-	120 grains
Yellow soft paraffin	-	-	-	-	240 grains
Ichthammol	-	-	-	-	60 grains
Zinc oxide	-	-	-	-	240 grains
Hydrous wool fat	-	-	-	-	120 grains
Lime water	-	-	-	-	120 grains
Olive oil	-	-	-	-	120 grains

Cases will occasionally react to painting each day with a solution of 0.5 per cent gentian violet in a mixture of one part methylated spirits to three parts of water.

Weak alkaline tar baths induce comfort and sleep, particularly if followed by the free application of a bland powder.

Sulphur has proved of value, but care must be taken not to induce a secondary sulphur dermatitis over intervening areas of unaffected skin.

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DERMATITIS OCCUPATIONAL

See SKIN, OCCUPATIONAL DISEASES

DERMATOPHYTIDES

See FUNGOUS DISEASES

DERMOID CYSTS

By W. E. GYE, M.D.

DIRECTOR OF THE IMPERIAL CANCER RESEARCH FUND

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2. ACQUIRED CYSTS	-	-	-	-	-	636

Reference may also be made to the following titles:

NECK, TUMOURS AND
OTHER MORBID
CONDITIONS

OVARY, DISEASES OF
TERATOMAS
TUMOURS

1.—CONGENITAL CYSTS

293.] Dermoid cysts belong to the group of congenital abnormalities. They should be distinguished on the one hand from teratoid cysts, and on the other from simple acquired cysts. True dermoid cysts arise from detached or sequestered portions of skin and are found in situations where during embryonic life coalescence takes place between cutaneous surfaces; ectodermal structures only are involved. In the teratoid cysts, of which the ovarian dermoid is the commonest example, tissues other than skin and cutaneous appendages are found. The ovarian 'dermoids' are properly classified as teratomas and discussed in the article under that title. The simple acquired cysts owe their origin to lesions sustained after birth.

The true (or sequestration) dermoid is a globular swelling occurring along the lines of closure of embryonic fissures; in the neck, for example, or at the inner and outer angles of the orbit, or in the middle line of the chest and abdomen. The cyst is lined with squamous epithelium and in its wall contains dermal appendages—hair and hair follicles, both sebaceous and sweat glands and ducts. The contents of the cyst have a characteristic cheesy and granular consistence, derived chiefly from the secretions of the sebaceous glands in the wall and from desquamated epithelial lining cells.

2.—ACQUIRED CYSTS

Acquired cysts, which arise as a consequence of injury in postnatal life, have a lining of squamous epithelium or of endothelium.

*Implantation
dermoids*

(1) Implantation dermoids are the result of the separation of a portion of adult epidermis consequent on injury. The dislocated tissue implanted in the subcutaneous connective tissue continues to grow, forming a space lined with squamous epithelium and filled with desquamated squames. In rare instances hair follicles are present in their walls. Such implantation cysts are of widespread distribution and may reach a large size. They are usually found on exposed surfaces, particularly on the hands of manual labourers, but traumatic dermoids occur in the cornea or iris. The capacity for growth is limited and malignant changes have not been observed.

*Atheromatous
cysts*

(2) Wens or atheromatous cysts, so-called from the resemblance of their contents to oatmeal gruel (*ἄθιππος*, groats), are another form of acquired cysts; they are lined with simple stratified epithelium. They are met with especially in the scalp, and are formed as a consequence of blockage of a hair follicle leading to retention of secretions: retention cysts. The cysts usually maintain a connexion with the surface.

*Distension
and exudation
cysts*

(3) Distension and exudation cysts are formed by dilatation of natural enclosed spaces. In the thyroid gland and in the pituitary body such cysts may occur. The common condition of hydrocele is brought about by accumulation of fluid in the tunica vaginalis. Here as also in distension cysts of bursae the wall is lined by endothelium.

Treatment

The treatment of true dermoid cysts is surgical excision.

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DESMOID TUMOURS

BY SIR HUMPHRY ROLLESTON, Bt., G.C.V.O., K.C.B., M.D.

Reference may also be made to the following title:

TUMOURS

(*Synonyms*.—Fibroma of the abdominal wall; hard fibroma; fibrosarcoma of the abdominal wall)

294.] The name desmoid (*δεσμός*, a band) was introduced in 1838 by Müller, but was not used until Säger in 1880 employed it, for growths with a structure resembling that of tendons. It has rather fallen out of use in favour of fibroma of the abdominal wall. *Nomenclature*

Eighty per cent of the cases occur in women, especially between the ages of twenty and forty, and trauma to the prominent abdomen of pregnancy has been given an important place in the aetiology of these tumours, which may also start in the scars of operations. About five hundred cases have been reported (Nichols). As in keloid growths, individual predisposition determines the development of these fibrous growths. *Aetiology*

The growth may arise (i) in or near the linea alba, usually below the umbilicus, from the fibrous tissue of the sheath of the rectus muscle, (ii) from the conjoint tendon of the internal oblique and transversalis muscles; among 56 cases 29 were derived from the sheath of the rectus and 27 from the internal oblique and transversalis muscles (Stewart and Mouat). Nélaton (1862) described 'fibrous tumours of the iliac crest' growing from the aponeurosis and periosteum of the iliac crest. The suggested origin from the round ligament of the uterus, from which fibromyomas may arise, has been disputed, partly on the ground that desmoid tumours never contain smooth muscular fibres. The tumours, which are nearly always single, are hard fibromas with a fair number of cells and well-formed blood-vessels. Myxomatous degeneration may occur. They tend to infiltrate voluntary muscle, and differ from keloids by including striated muscular fibres which, according to Stewart and Mouat, show a process of de-differentiation into multinuclear plasmodial masses resembling foreign-body giant cells. These authorities could not find any evidence that sarcomatous change ever occurs. *Morbid anatomy*

These painless tumours may reach the size of a hen's egg before they are, and then often accidentally, discovered. They do not become adherent to the skin and are not tender. When comparatively small they are round, oval, or elongated, but when large tend to be lobulated. Their growth is slow at first, increases during pregnancy, and if allowed *Clinical picture*

may reach a great size, rapid increase being due to myxomatous change rather than to cellular proliferation.

Prognosis

The prognosis is favourable, and removal very successful. Recurrence is due to imperfect removal, not to malignancy. It has been stated that the appearance of several tumours in the abdominal wall after removal of a single growth is part of the tendency of benign tumours to be multiple, and not evidence of malignancy (Olshausen).

Differential diagnosis

They must be distinguished from tumours in the abdominal cavity, such as uterine fibromyomas, ovarian cysts and solid tumours, omental growths, hydatid and other cysts, and distension of the gall-bladder.

Bouchacourt's sign

According to Stewart and Mouat the most important single diagnostic sign is that when the patient contracts the abdominal muscles, the tumour at once becomes completely immobilized (Bouchacourt's sign). It is less easy to differentiate desmoid from other formations in the abdominal muscles, such as a haematoma, gumma, or intramuscular lipoma.

Treatment

Removal should be carried out early, when the tumour is so small that the risk of so weakening the abdominal wall that hernia may follow, is avoided. In inoperable cases X-ray exposures have been recommended.

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DHOBIE ITCH

See FUNGOUS DISEASES

DIABETES INSIPIDUS

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Reference may also be made to the following title:

PITUITARY GLAND DISEASES

1.-DEFINITION

295.] Diabetes insipidus is a long continued, abnormally increased secretion of non-saccharine urine, which is not caused by a diseased condition of the kidney (Frank, 1794).

2.-AETIOLOGY AND PATHOLOGY

The condition is not common and is said to be more frequent in the male than in the female. It may occur in young children but usually appears in middle-age.

The experiments by Starling and Verney in 1925 and 1929 on the isolated kidney, which is perfused with blood, are of great importance in understanding the pathology of the condition. They showed that the urine excreted by the isolated kidney is very dilute, contains very little chloride, has a low specific gravity, and so resembles that of a patient with diabetes insipidus. When pituitary (posterior lobe) extract is added to the perfusion fluid the kidney recovers its power of excreting a concentrated urine and of excreting chlorides. Verney was able to show that it was the pressor factor of the extract, called vasopressin, which

*Starling and
Verney's
experiments*

was responsible for this effect, whereas the oxytocin factor, which causes contraction of the uterus, had no effect. These experiments confirmed the previous observations on the action of pituitary (posterior lobe) extract on the intact animal and on patients with diabetes insipidus, and are of great importance since they were performed on the isolated kidney. They suggest that the pituitary extract acts on the tubules of the kidney and enables them to control the water and chloride excretion. On this hypothesis the symptoms of the disease arise from lack of the extract. This is stored in the posterior lobe of the pituitary gland, but it is not certain whether it is formed there. The problem, however, is not as simple as this. The complete removal of the pituitary gland in animals causes polyuria, among other symptoms, in the great majority of the cases. The polyuria may be only transient and soon disappear or it may not occur at all.

*Hypo-
thalamus
puncture*

It has been shown by Camus and Roussy, Houssay, Bailey and Bremer, that a puncture of the hypothalamus always causes polyuria, and it has been suggested that the symptoms which arise after removal of the pituitary gland are really due to injury of the hypothalamus in the course of the operation. Fulton and Bailey have shown that tumours involving the tuber cinereum cause a well-marked polyuria among other symptoms. These observations are difficult to correlate with the action of pituitary extract on patients with diabetes insipidus, and with Starling and Verney's experiments on the isolated kidney.

*Post-mortem
findings*

The pathological lesions which are found at necropsy in cases of diabetes insipidus include fracture of the base of the skull, tuberculous and syphilitic basal meningitis, and tumours of the pituitary gland or tuber cinereum. It is usually difficult to determine the lesion during life.

3.—CLINICAL PICTURE

Polyuria

*General
condition*

The symptoms usually start gradually, although they may appear suddenly either after a fracture of the base of the skull or without any obvious injury. Great thirst and polyuria are the outstanding symptoms. The volume of the urine is much increased; in a mild case 4,000 c.c. (7 pints) are excreted, and in the severe cases the volume of urine may reach 8,000 c.c. (14 pints), 12,000 c.c. (21 pints), or even more. However much the patient may drink he remains thirsty, and the more he drinks, the more he suffers from the frequent micturition which is very inconvenient in the daytime and which disturbs his sleep every one or two hours during the night. The patient loses weight and the subcutaneous tissues of the face and body are obviously shrunken; the mouth and tongue are very dry and the skin becomes dry and scaly; constipation occurs and may be severe. The appetite is usually unaffected but may be very large, and abdominal discomfort sometimes occurs. Patients suffer considerably from nervous strain due to the need for water and the constant micturition.

The urine is very pale, its specific gravity is 1001 to 1003, and as a rule it does not contain albumin, sugar, or casts. Both albumin and sugar may be present on occasion and their presence makes the diagnosis difficult. *Examination of urine and blood*

The blood is concentrated and its volume considerably reduced; the haemoglobin may be raised above 100 per cent and the red cells above 5,000,000 per c.mm. A severe degree of anaemia may be present in spite of a high haemoglobin figure, since it is masked by the concentration of the blood. When treatment is instituted the volume of the blood returns to normal and the haemoglobin percentage decreases.

If a tumour or basal meningitis is present the so-called 'neighbourhood symptoms', ocular paralyses and bitemporal hemianopia, may be present and should always be searched for. *'Neighbourhood symptoms'*

4.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The following conditions must be considered and carefully excluded: diabetes mellitus, chronic interstitial nephritis, polycystic disease of the kidneys, polydipsia, pituitary tumour, fracture of the skull, and syphilis.

The nature of any reducing substances in the urine must be ascertained; if glucose is found, the blood-sugar should be estimated one hour after a good carbohydrate meal, and if necessary a sugar tolerance test should be performed. The percentage amount of sugar in the urine of patients with diabetes mellitus excreting 4,000 c.c. (7 pints) is always large, 5 to 10 per cent, and the specific gravity is high, 1030 to 1040. Difficulties in diagnosis only occur when a mild diabetes mellitus exists at the same time as a diabetes insipidus. *Diagnosis from diabetes mellitus*

In chronic interstitial nephritis polyuria is sometimes well marked but rarely exceeds 3,000 to 4,000 c.c. (5 to 7 pints); it is unaccompanied by real thirst. The urine is pale and of low specific gravity and the amount of albumin may be very small; casts are usually found when a fresh specimen of urine is examined microscopically. The blood urea may be raised and the urea clearance test may be abnormal. *From chronic interstitial nephritis*

In polycystic disease of the kidneys, the symptom of polyuria may be as great as in chronic interstitial nephritis; a tumour can usually be felt in one or both loins, and the performance of an intravenous pyelogram will establish the diagnosis. *From polycystic disease of the kidneys*

Polydipsia is a hysterical manifestation and is often difficult to diagnose. The patient drinks a great deal and the polyuria is marked. It is unusual for such a patient to drink more than 4,000 c.c. (7 pints) and the condition will be confused with the mild form of diabetes insipidus. The associated signs of dry mouth, wrinkling and dryness of the skin, and loss of weight, will be absent, as the patient only excretes the excess of the water which is drunk. The specific gravity of the urine is low but is usually a little higher than in diabetes insipidus. The diagnosis is best made by measuring the amount of urine passed *From polydipsia*

at each voiding throughout the day and expressing the result in cubic centimetres per hour; the result should be plotted on a chart. If the patient has a polydipsia there will be periods in the day when the output per hour decreases to a small amount, and this is especially the case at night unless the patient is a restless sleeper and drinks because he is awake. A record should be kept for 2 or 3 days and then the effect of a subcutaneous injection of 10 units (1 c.c.) of pituitary (posterior lobe) extract watched. If the patient has a true diabetes insipidus, the excretion rate per hour will be greatly reduced for some hours and the thirst will be relieved, but if the patient has a polydipsia little change will be observed in the excretion rate and the thirst will be unaltered. The diagnosis is confirmed by reducing the intake of fluid each day by 300 c.c. ($\frac{1}{2}$ pint). The patient with polydipsia will not suffer from thirst under these conditions, whereas the one with diabetes insipidus will suffer acutely after some days and will usually succeed in stealing water from some other source.

Radiology

*Wassermann
test*

An X-ray examination of the skull should always be made to discover whether a lesion of the pituitary gland is present, or, in cases of head injuries, to determine the site and extent of the fracture. The Wassermann reaction should always be tested as gummatous meningitis of the base of the skull may be present.

5.—TREATMENT

*Administra-
tion of
pituitary
extract*

The appropriate treatment should be given for the primary disease if it is known, e.g. disease of the pituitary gland or gummatous meningitis. The symptoms can be completely relieved by giving an adequate amount of the pressor factor (vasopressin or pitressin). This is usually prescribed in the form of pituitary (posterior lobe) extract, as the presence of the oxytocin factor causes no symptoms, and it has the advantage of being much cheaper. If the patient is pregnant the oxytocin in the pituitary extract will cause so much pain from the contractions of the uterus that the full dose cannot be tolerated (writer's case). In such a case the pressor factor should be used. Pituitary (posterior lobe) extract has been standardized by the Health Committee of the League of Nations and 1 c.c. contains 10 units. It is usually sold in glass ampoules each containing 5 or 10 units; this is inconvenient and expensive when 4 or 7 units is the correct dose and the extract should be dispensed in a 5 or 10 c.c. rubber-capped bottle. The syringe should be graduated in tenths of a c.c., fitted with a No. 20 stainless steel needle, and kept in a metal tube fitted with surgical or industrial spirit. The pituitary (posterior lobe) extract should be injected into the subcutaneous tissues of the thigh or arm. The correct dose is gauged by watching the effect of 5 or 10 units on the hourly rate of urine excretion, and the dose must be increased until the patient is comfortable throughout the day; it may be necessary to give two or three doses. If the dose of the extract

Dosage

is too big the patient will suffer from headaches or intestinal cramps. When the correct dose has been given the patient will lose all his symptoms and feel perfectly well. He should understand that the dose is not constant and that if he improves it will be decreased, and that if infections, e.g. influenza, occur it must be increased. It is probable that the extract will have to be taken for the rest of the patient's life but this is not always the case. The polyuria which occurs after a fractured skull is usually transient. If the lesion is due to syphilis, energetic treatment with N.A.B. and bismuth will cause the symptoms to disappear. In some cases the symptoms cease without any treatment.

*Modifications
in dosage*

The pituitary extract is absorbed through the nasal mucous membrane if it is either sprayed up the nose or applied to the turbinate bones on a piece of lint. The dose which is given in any particular case is larger than that which is effective by the subcutaneous route, and the results are not so constant.

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DIABETES MELLITUS

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Reference may also be made to the following titles:

CATARACT GLYCOSURIA, NON-DIABETIC
URINE EXAMINATION

I.—DIABETES MELLITUS

1.—DEFINITION

296.] Diabetes mellitus is a disorder of metabolism in which there is persistent hyperglycaemia and glycosuria associated commonly with excessive thirst, polyuria, and progressive loss of weight.

2.—PATHOGENESIS

Von Mehring and Minkowski showed in 1889 that diabetes mellitus could be produced experimentally in dogs by extirpation of the pancreas and, until recently, most of the work on the pathogenesis of diabetes has centred round this discovery. The pathology of diabetes mellitus was localized in the islets of Langerhans at the beginning of this century by Opie, and the evidence for the pancreatic theory of diabetes seemed complete when, in 1922, Banting and Best succeeded in preparing insulin from the islet tissue of glands in which ligation of the pancreatic duct had produced degeneration of the acini. Furthermore, signs of chronic hyperinsulinism have been observed on a number of occasions in association with adenoma of the islet cells.

Recently the field of research has moved from the pancreas to other ductless glands, of which the pituitary, adrenals, and thyroid appear to be the most important. The association between diabetes and acromegaly is well known, and Houssay has shown that the severity of experimental diabetes in pancreatectomized dogs can be diminished by previous or subsequent hypophysectomy, and further that implantation of the anterior lobe in the hypophysectomized toad protects against hypersensitiveness to insulin, and re-establishes diabetes after removal of the pancreas. Later Houssay and Evans discovered independently that extracts of the anterior pituitary contain a diabetogenic hormone which, if injected into dogs, produces hyperglycaemia, glycosuria, and polyuria. The posterior lobe of the pituitary at present appears to be less intimately

*Pancreatic
theory*

*Other
endocrine
glands*

associated with diabetes mellitus, but pituitary (posterior lobe) extract, like adrenaline, antagonizes the action of insulin, both substances being used in the treatment of hypoglycaemia.

Adrenaline, when injected subcutaneously, antagonizes insulin with the production of hyperglycaemia, and stimulation of the splanchnic nerves and puncture of the floor of the fourth ventricle have a similar effect, provided that the adrenal glands are intact. Indirect stimulation by fear or excitement also has this result, but disease or atrophy of the adrenals, such as occurs in Addison's disease, has not any effect on the blood-sugar level.

The association of hyperglycaemia and glycosuria with hyperthyroidism is not uncommon, and animal experiments suggest that excess of thyroid secretion may impair the liver's normal mechanism of storing glycogen.

3.—AETIOLOGY

<i>Age</i>	Diabetes mellitus occurs at all ages, but the maximum incidence of its onset is between the ages of 45 and 55, after which it falls, and the disease tends to become mild. The incidence in the coloured races is probably similar to that in white people, among whom the Jews and, to a lesser extent, the Irish appear to be particularly susceptible. It is, however, noteworthy that the incidence in young Jews is no higher than in the young of other races. Heredity has long been recognized as a factor in the aetiology, but only recently Joslin, White, and their co-workers in America have brought forward considerable evidence that this disease is in many cases transmitted as a simple Mendelian recessive, a theory which, if confirmed, is of great importance in the future prevention of diabetes. Associated probably with heredity and endocrine dysfunction is obesity, the aetiological importance of which is also well known. The exact nature of this association is uncertain, but it would seem that obesity acts as the exciting factor to produce the disease in those with an inherited susceptibility.
<i>Incidence</i>	
<i>Heredity</i>	
<i>Obesity</i>	
<i>Other factors</i>	
	Worry and infection have also been considered as aetiological factors, but, although both may aggravate an existing diabetes, there is no evidence that they ever produce the disease in a non-diabetic subject.

4.—MORBID ANATOMY

In fatal cases of uncomplicated diabetes mellitus characteristic post-mortem changes are conspicuously absent and, although the pancreas may be smaller than normal or sclerotic, these findings are exceptional. Microscopically the commonest lesion consists of hydropic degeneration and vacuolation of the beta cells of the islands of Langerhans. These changes, first described by Weichselbaum, are commoner than any other single lesion, but are absent in many cases, especially in children

Pancreatic lesions

in whom it has been suggested that the reduction in insular tissue is congenital rather than the result of disease. Fibrosis of the islets, according to some authorities, occurs almost as frequently as hyalinization, and lymphocytic infiltration is often present. Sclerosis of the acinar tissue may occur alone or in association with lesions of the islets, and may be the result of previous pancreatitis. Pancreatic calculi preceding diabetes are rare; in 1936 Mayo collected 125 examples.

The accumulation of lipoids in the cells of the reticulo-endothelial system in the form of cholesterol esters occurs most often in cases with well-marked lipaemia (including often hypercholesterolaemia). Since the introduction of insulin such cases have become rare. The same pathological process may give rise to xanthoma diabeticorum and the formation of raised yellow patches in the aorta and other large vessels. No constant pathological changes in the pituitary have been described, although some observers claim to have found proliferation of the eosinophil cells of the anterior lobe. Haemochromatosis or bronzed diabetes (see HAEMOCHROMATOSIS) is a condition in which a true diabetes results from the destructive action of haemofuscin on the pancreas.

Lesions in reticulo-endothelial system

Pituitary lesions

Haemochromatosis

5.—CLINICAL PICTURE

A subdivision is usually made into mild, moderately severe, and severe types according to the presence or absence of symptoms, their intensity, and the rapidity of their onset. In mild cases symptoms may be entirely absent or confined to a mild degree of polyuria or undue fatigue at the end of the day. This type occurs most commonly among elderly people, and is often associated with obesity and arteriosclerosis. In the moderately severe and severe types the classical symptoms of thirst, polyuria, excessive fatigue, and loss of weight are usually present, their onset in moderately severe cases being typically gradual over a period of months, whereas in the latter they may appear with dramatic suddenness, the patient being able to name the exact day and even hour when intense thirst began. In addition to these classical symptoms there are others which are less constantly present. Pruritus is especially common in women, but also occurs in men in whom there may be an associated inflammatory oedema of the prepuce.

Clinical types

Visual disturbances are not uncommon, and may be due to temporary or to permanent changes in the eyes. The temporary changes cause impairment of vision which varies at different times of the day, and is in some way connected with the level of the blood-sugar. They may occur with high blood-sugars in untreated diabetics, or with the recently lowered levels of those receiving treatment, but always disappear when the disease is controlled. The permanent changes, with the exception of true diabetic cataract, are uncommon in young diabetics, and include senile cataract and retinitis. Diabetic or floccular cataract is rare and may develop and mature very rapidly in young diabetics with high blood-

Visual changes

sugars. Diabetic retinitis is often associated with arteriosclerosis, but can be distinguished from the hypertensive type by its deeply situated haemorrhages and waxy exudate. The prognosis for recovery in conditions due to permanent changes is bad, but treatment of the diabetes may greatly retard their progress.

Excessive hunger is not uncommon in young diabetics; constipation is the rule rather than the exception and, like muscular cramps, has been attributed to dehydration but, unlike the muscular cramp, frequently persists in balanced cases. Well-developed diabetic neuritis is uncommon, but a mild form of this condition, in which pains in the legs, diminished vibration sense, and possibly loss of ankle-jerks are the principal features, is frequently seen. Trophic changes, particularly in the feet, are more often the result of vascular than nervous disease.

*Relation to
arterial
disease*

The association between diabetes mellitus and arterial disease is not fully understood, but it is known that very advanced arteriosclerosis may sometimes be present in young diabetics, and that the incidence of calcification of the vessels of the lower limbs in long-standing cases of diabetes mellitus is much higher than in non-diabetic controls. This probably accounts for the comparative frequency of gangrene of the lower extremities in this disease.

The lowered resistance of the unbalanced diabetic to infection may lead to a diagnosis of diabetes mellitus when a patient is attacked by a carbuncle, boils, or pulmonary tuberculosis, but it must be remembered that infection may lower the carbohydrate tolerance of a non-diabetic, with resulting transient hyperglycaemia and glycosuria.

6.—DIAGNOSIS

The diagnosis of diabetes mellitus is made from the history of the symptoms of the disease, if these are present, together with an examination of the urine and the blood. Physical examination rarely provides any signs of diagnostic value, but is essential to correct treatment and accurate prognosis.

*Physical
signs in
mild cases*

In mild cases physical signs of diagnostic value are likely to be absent, the patient appearing healthy or not uncommonly obese. There may be changes in the eyes in the form of cataract or diabetic retinitis, or evidence of arterial disease, but diabetes may not be suspected until the urine is tested for sugar.

*In severe
cases*

In severe cases, however, the patient is usually found to have lost weight and may be extremely wasted. The skin may be dry and inelastic; the tongue dry, red, and furred; and the breath charged with acetone.

*The
examination
of urine*

The urine is typically pale in colour, copious in amount, and of high specific gravity. Sugar is present in large quantities and, if 6 drops of urine and 3 c.c. of Benedict's solution are placed in a test tube and stood in boiling water for 5 minutes, a brick-red colour is obtained.

When ketone bodies are present Rothera's nitroprusside test for aceto-

acetic acid gives a permanganate colour which develops within a few seconds. A trace of albumin is often found, and in diabetic coma there may also be large numbers of casts.

The discovery of a reducing substance in the urine, even in the absence of all symptoms of diabetes mellitus, should never be disregarded until its nature and the cause of its presence have been investigated. The substances occurring in the urine which may reduce Benedict's solution can be divided into non-sugars and sugars. The non-sugars include creatinine, homogentisic and salicylic acids, and such drugs as chloral, carbolic, camphor, and turpentine which are excreted in combination with glycuronic acid. The sugars include dextrose, laevulose or fructose, lactose, and pentose. If the existence of the former group is borne in mind, and also the fact that the reduction produced by its members is usually partial and often atypical in appearance, it is usually not difficult to exclude it.

*Reducing
substances
found in
urine*

Sugars

When the reduction is due to the presence of a sugar it is usually unnecessary to identify it, unless the patient is in the late months of pregnancy or nursing, when the possibility of lactosuria must be considered. Fructosuria may follow the eating of fruit rich in this sugar as also, in like circumstances, may pentosuria, although the latter condition is usually familial; both may rarely be associated with a true diabetes.

The type of sugar present can, if necessary, be determined by means of the glucosazone, fermentation, and polarimetric tests, but it is usually more important to discover whether the presence of sugar in the urine is due to an increase of that substance in the blood or to an alteration in the renal threshold.

7.—DIFFERENTIAL DIAGNOSIS FROM RENAL GLYCOSURIA

Renal glycosuria is usually hereditary and familial. The cardinal requirements for diagnosis are persistent glycosuria relatively independent of diet, with absence of hyperglycaemia, polyuria, and thirst. The amount of sugar excreted daily in the urine varies greatly, and may be as little as 3 grams or as much as 30 grams but tends to be more or less constant for the same patient.

The most conclusive method of distinguishing between diabetes and renal glycosuria is by means of a glucose tolerance test, but this may not always be necessary. If the blood-sugar is estimated about 1½ hours after a full carbohydrate meal and found to be above 180 mgm. per 100 c.c., it is almost certain that the patient is diabetic, but in all doubtful cases a tolerance test is desirable.

Before the glucose tolerance test is carried out the patient should have been on an unrestricted carbohydrate diet for several days; otherwise misleading results may be obtained. The test should be carried out in the morning after the patient has fasted since the evening meal of the

*Glucose
tolerance
tests*

previous day. Blood is first taken for a fasting blood-sugar after which 50 grams of glucose are given in about 100 c.c. of water. Further samples are taken at half-hourly intervals for 2 hours and the blood-sugars plotted in the form of a curve. Samples of urine are also collected every half-hour or hour, and tested for sugar and ketone bodies.

*Normal
blood-sugar
curve*

Fig. 74 shows a normal curve and also curves typical of mild and severe diabetes. In the normal the fasting blood-sugar is low, 80 to 120 mgm., and the curve rises rapidly to a maximum of 180 mgm.

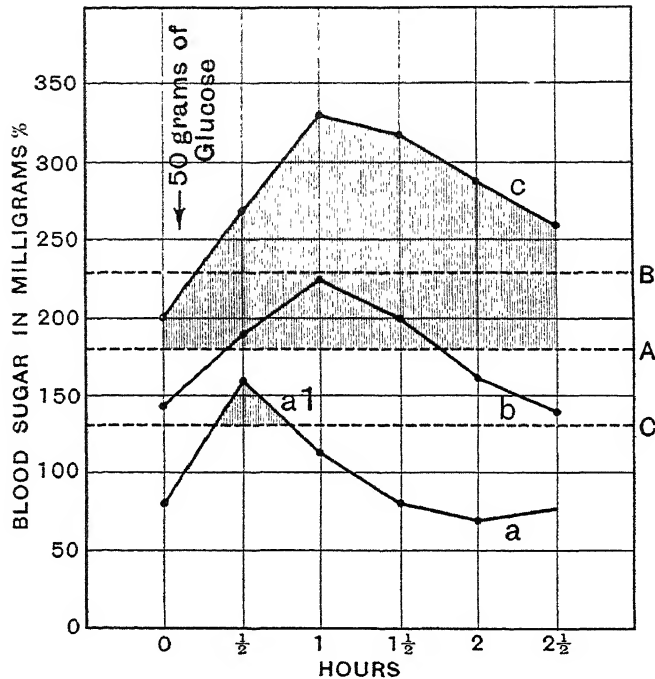


FIG. 74.—Blood-sugar curves in glucose tolerance tests. A, normal renal threshold; B, raised renal threshold; C, low renal threshold. a, normal curve; b, mild diabetic curve; c, severe diabetic curve; a1, renal glycosuria. Shaded areas represent sugar in urine

(capillary blood) or 150 mgm. (venous blood) by the end of the first hour, after which it falls steeply, and returns to the fasting level within $1\frac{1}{2}$ or 2 hours.

*Diabetic
curve*

In mild cases of diabetes the fasting level is normal or only slightly raised, but in more severe cases it is comparatively high. The curve takes longer to reach its maximum, which varies according to the severity of the disease, but usually exceeds 200 mgm., and falls slowly so that the blood-sugar after 2 hours is still appreciably raised—180 to 250 mgm. or more. If the renal threshold is normal (180 mgm. per 100 c.c.) sugar will be absent in normal cases, but present in diabetics for as long as the blood-sugar exceeds this figure. In renal glycosuria there is a normal response to the glucose tolerance test but, owing to the lowered thresh-

old of the kidney, sugar appears in the first two or three specimens. The threshold is, however, sometimes raised to 250 mgm. or even 300 mgm., and glycosuria may not then occur although the blood-sugar is very high.

MacLean described a peculiar type of curve in which the blood-sugar '*Lag*' curve rises steeply to between 200 and 250 mgm. per 100 c.c. at the end of $\frac{1}{2}$ hour, but returns to normal in $1\frac{1}{2}$ to 2 hours. This curve has been called the '*lag*' curve on the assumption that the mechanism for controlling the blood-sugar level is normal but delayed in action. Another possible explanation is that rapid emptying of the stomach causes an increased rate of absorption of the glucose; this view is supported by the observation that lag curves are not uncommon in patients suffering from duodenal ulcer. There is no good reason to believe that this type of curve indicates an incipient diabetes, and it is now generally held that it has no prognostic significance.

8.—TREATMENT

From what has been said of the aetiology of diabetes there would appear *Prevention* to be two possible methods of preventing the disease. If the views expressed on heredity are correct, the transmission of the disease in cases in which the condition is transmitted as a simple recessive can be prevented by restricting the marriage of the patients to healthy persons with no family history of diabetes. The incidence might further be reduced if obesity could be avoided generally, and particularly by the relatives of diabetics whose optimum weight should be 5 to 10 per cent below the normal standard.

The aim of treatment in established diabetics should be to provide *General principles* the patient with an adequate and palatable diet, and at the same time to keep the blood-sugar within normal limits (80 to 180 mgm. per 100 c.c.) and the urine free from ketone bodies. The degree of success with which this object may be achieved depends very largely upon the mentality of the diabetic and the severity of the disease. In diabetes, in order to obtain the best results, the patient should be taught the general nature of the metabolic disturbances in the disease and the principles underlying its treatment. In addition, diabetics should learn how to vary their diets, inject insulin, and examine their urine daily for sugar.

The general method of treatment is the same in all cases of diabetes, and consists of diet either with or without insulin. The details of diet, and dosage of insulin if required, depend upon a number of factors of which the most important is the severity of the disease.

(1)—Very Mild Cases

Symptomless glycosuria as a manifestation of diabetes mellitus usually occurs in the elderly, and may be prevented by simple restriction of carbohydrate. The substitution of saccharine for sugar, and the limita-

tion of foods rich in carbohydrate, such as bread, cakes, pastry, and potatoes, may be sufficient to render the urine sugar-free, but it is wise also to determine the blood-sugar as, in cases with a raised renal threshold, this may be comparatively high even when glycosuria is absent. The possibility that these cases may become more severe must be remembered and, if sugar reappears in the urine passed after the evening meal, stricter methods of treatment should be instituted.

(2)—Moderately Severe and Severe Cases

Choice of methods

There are two possible ways of treating these patients: (a) a diet just sufficient for the basal requirements of the body is given together with insulin, (b) a brief period of under-nutrition is followed by a rapid increase in diet, insulin being given if diet alone fails to keep the urine sugar-free. In most cases the former is the more suitable and quicker method, but when the patient strongly objects to the injection of insulin, or when the mild character of the disease suggests that insulin may not be necessary, the second method has definite advantages.

(a) Maintenance Diet with Insulin

Estimation of caloric requirements

If this method is adopted it is first necessary to estimate the basal caloric requirement of the patient; this depends on the surface area of the patient, and can be ascertained from appropriate tables. An approximate result can be obtained by multiplying the patient's ideal weight in pounds by 11·3; this only applies to adults, special figures being necessary for children. The total calories must then be divided between carbohydrate, protein, and fat, and converted in articles of food and meals. The protein requirement in adults is relatively fixed at 0·5 gram per pound of body weight, and it is easiest therefore first to calculate the required amount of protein, the remaining calories being then divided between carbohydrate and fat. The way in which this is done can best be illustrated by an example.

Balance of the diet

An adult of 140 lbs. requires 1,582 calories ($140 \times 11\cdot3$). The protein allowance is 70 grams, and this figure multiplied by 4·1 (the calorie value of protein) gives 287 calories, and leaves 1,295 to be divided between carbohydrate and fat. The correct distribution of the remaining calories raises a difficult and controversial problem in the treatment of diabetes to which reference is made below, but for the present it is sufficient to say that not less than 100 grams of carbohydrate should be given, and this multiplied by 4·1 (the calorie value of carbohydrate) gives 410 calories; 885 calories are now left for the fat, and this figure divided by 9·3 (the calorie value of fat) gives approximately 95 grams of fat. The correct diet therefore contains 100 grams of carbohydrate, 70 grams of protein, and 95 grams of fat, having a total calorie value of 1,580.

(b) 'Ladder Diet'

'Ladder diet'

In the alternative method of treatment the patient fasts for one day at the outset, and is then put on successive diets of increasing calorie

value. A convenient scheme for this method of treatment is Graham's 'ladder diet', in which the amount of food is increased daily from 12 grams carbohydrate, 36 grams protein, and 48 grams fat on the first day, to 72 grams carbohydrate, 71.4 grams protein, and 97.5 grams fat on the tenth day. If the patient's urine is sugar-free on the diet of the tenth day the carbohydrate is increased every three days by 10 grams until 100 grams are being taken. It will be seen that this diet now closely resembles the maintenance diet described above (p. 652), and the further treatment is the same by both methods. On account of its low carbohydrate and relatively high fat content the ladder diet should not be prescribed for patients whose urine contains ketone bodies.

When the ladder diet is used the urine in mild cases becomes sugar-free after the second or third day; if, however, sugar persists, the patient will require insulin, and should be put on a maintenance diet without further delay.

If the patient is sugar-free on the above diet, and able to work without loss of weight or hunger, insulin may not be necessary, but it is probably better for him to have more carbohydrate—130 to 180 grams—and, if necessary, a small dose of insulin. When insulin is not required, the diet should be distributed evenly throughout the day; this applies particularly to the carbohydrate portion.

The conversion of food values into articles of diet and meals is the most difficult task which confronts diabetics, and upon the measure of their success in so doing depends the extent to which the disease differentiates them from their fellows. In order to overcome this difficulty a simple method was introduced by Lawrence in the form of 'line rations'. Each line consists of a black and a red portion, the former containing 10 grams of carbohydrate and the latter 7.5 grams of protein and 15 grams of fat, the caloric value being 210. By dividing the total caloric requirement by 210 the correct number of lines is obtained, and from these a varied diet can be arranged. If this method is used without modification it will be seen that 100 grams of carbohydrate are balanced by 150 grams of fat, the protein being 75 grams. As it is now agreed that better results are obtained if the carbohydrate is kept relatively high and the fat low, the 'line ration' scheme must be modified in one of the ways suggested by Lawrence to achieve this end.

Line rations

A simpler way of arranging a diet is by means of a food table such as is shown in Fig. 75.

In this the amounts of the various foods which contain 5 grams of carbohydrate on the one hand, and 7 grams each of protein and fat on the other, are arranged in lists. To these are added a list of vegetables and other articles of food which contain little or no carbohydrate, and can be taken without restriction. The table shown is that used at St. Bartholomew's Hospital, London, and contains only the more common foods; more comprehensive lists can easily be compiled, and infinite variety thus obtained.

For example, a patient on a diet containing 150 grams carbohydrate,

FOOD TABLES

CARBOHYDRATE FOODS

Each portion contains about 5 grams carbohydrate (5 g. C.)

Ounces		Ounces	
Biscuit (plain)	- $\frac{1}{2}$	Milk	- $3\frac{1}{2}$
Bread	- $\frac{1}{2}$	Oatmeal (dry)	- $\frac{1}{2}$
Force or Cornflake	- $\frac{1}{2}$	Rice or Tapioca (dry)	- $\frac{1}{2}$

VEGETABLES. Group II

Beetroot	- 2	Parsnips	- $1\frac{1}{2}$
Carrots	- 4	Peas (green)	- 2
Haricot Beans	- 1	Peas (dried)	- 1
Leeks	- 4	Potatoes	- 1
Onions	- 6	Tomatoes	- 6
		Turnips	- 7

FRUITS

(Weighed with stones but no peel)

Apple (raw)	- $1\frac{1}{2}$	Grapes	- $1\frac{1}{2}$
Apple (stewed)	- 4	Greengage	- $1\frac{1}{2}$
Apricot (fresh)	- 3	Melon	- $3\frac{1}{2}$
Banana	- 1	Orange	- 2
Blackberries	- 3	Peaches	- 2
Cherries	- $1\frac{1}{2}$	Pears	- 2
Currants (red or black)	- $3\frac{1}{2}$	Prunes	- 1
Damsons	- 2	Plums	- 2
Gooseberries (raw, ripe)	- 2	Raspberries	- 3
Grape Fruit	- $3\frac{1}{2}$	Strawberries	- 3
		Chestnuts	- $\frac{1}{2}$

VEGETABLES. Group I

The following contain little or no carbohydrate

Asparagus	Gooseberries (unripe and stewed)	Rhubarb	Marmite
Brussels sprouts	Marrow	Water Cress	Clear Meat or Chicken Soup
Cabbage	Lettuce	Tea	Saccharine
Cauliflower	Mustard and Cress	Coffee	Vinegar
Celery	Radishes	Lemon Juice	Salt
Cucumber	Seakale	Soda Water	Pepper
French Beans	Spinach	Meat Extract	Mustard

PROTEIN AND FAT FOODS

The following portions contain about 7 grams protein and 7 grams fat (7 g. P.F.), and may be exchanged one for another without causing any real difference in food values.

MEATS	Ounces	FISH	Ounces
Beef	- 1	Herring (salt or fresh)	- between
Lamb	- 1	Salmon	-
Mutton	- 1	Sardines	- calories
Pork	- 1	Mackerel	- diabetes
Veal	- 1	With the addition of $\frac{1}{4}$ oz. Butter	
Tripe	- $1\frac{1}{2}$	White Fish	- client to
Ham	- $\frac{3}{4}$	Smoked Haddock	- $1\frac{1}{2}$
With the addition of $\frac{1}{4}$ oz. Butter			
Chicken	- 1		
Rabbit	- 1	1 Egg	
Game	- 1	Cheese	- 1
With the reduction of $\frac{1}{4}$ oz. Butter			
Bacon	- $1\frac{1}{2}$ ounces		

FATS

The following portions contain about 5 grams of Fat:

	Ounces
Cream (average)	- $\frac{1}{2}$
Cream (Devonshire)	- $\frac{1}{4}$
Butter	- $\frac{1}{2}$

SPECIMEN DIET

Containing approximately Carbohydrate (C.), 150 grams; Protein (P.), 75 grams; Fat (F.), 95 grams. Calorie value = 1,850

(Arranged for insulin morning and evening)

	Oz.	5 g. C. PORTIONS	7 g. P.F. PORTIONS	C. IN GRAMS	P. IN GRAMS	F. IN GRAMS
BREAKFAST						
1 egg	-	..	1	..	7	7
Bacon	-	1	1	..	4.7	10
Bread	-	3	..	45	6	0.9
Tea or coffee (ground) with Milk from allowance						
Total	-	9		45		
MIDDAY MEAL						
Meat or fish (Fig. 75)	-	3	3	..	21	21
Vegetables or salad in Group I as desired						
Potatoes	-	4	..	20	..	..
or Bread	-	1½				
Fruit (see Fig. 75)	-	10	..	..
Milk (additional to allowance) as custard or junket	-	3½	1	5	3.5	3.5
Total	-	7		35		
TEA						
Bread	-	1	3	15	2	0.3
or Unsweetened biscuit	-	¾	..			
1 egg or ¾ ounce cheese	-	..	1	..	7	7
Green salad in Group I (Fig. 75) if desired						
Tea with milk from allow- ance						
Total	-	3		15		
EVENING MEAL						
Meat or fish (Fig. 75)	-	2	2	..	14	14
Vegetables in Group I (Fig. 75) as desired						
Potatoes	-	4	..	20	..	..
or Bread	-	1½				
Fruit	-	10	..	..
Unsweetened biscuit	-	¾	3	15	2	0.3
or Bread	-	1	..			
Total	-	9		45		
Daily allowance of milk	-	7	..	10	7	7
„ „ butter	-	1	..	..	..	25
TOTAL	-	30	8	150	74.2	96.0

FIG. 76

70 grams protein, and 95 grams fat will take thirty 5-gram portions of carbohydrate, eight protein-fat portions, and 1 ounce of butter, the additional protein being made up from the bread. The specimen diet in Fig. 76 is made up in this way from Fig. 75, and is designed to be taken with insulin.

(3)—Treatment with Insulin

Action of insulin

All but the mild cases of diabetes need insulin. When injected, insulin lowers the percentage of sugar in the blood, and promotes its storage and utilization in the liver, muscles, and skin in the form of glycogen. The number of grams of carbohydrate metabolized by 1 unit of insulin is not known, and is almost certainly a variable quantity. Different observers have placed the figure as low as 1 and as high as 8.75, but it probably depends upon several factors, and under usual conditions

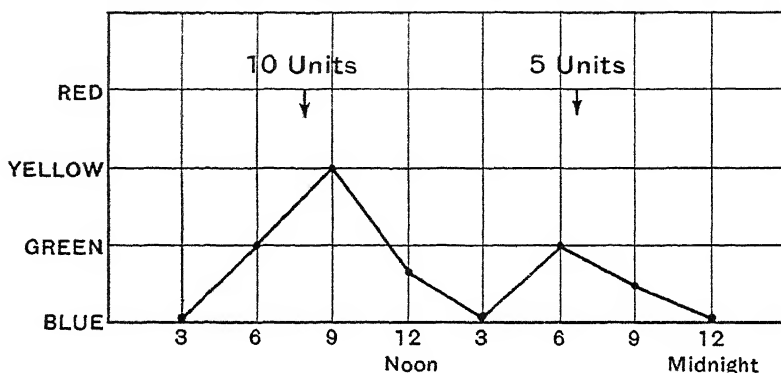


FIG. 77.—The colours represent the results of urine tests by Benedict's qualitative reagent

approximates to 4. It is known that the efficiency of insulin is impaired by over-action of the pituitary, thyroid, and adrenals, which may account for the greater susceptibility of some patients than others. Infections, ketosis, excessive fat, and carbohydrate deficiency also have an adverse effect on its action, whereas it appears to be enhanced by the presence of abundant carbohydrate.

It is convenient, but not absolutely necessary, to keep the patient in bed during the early stages of treatment with insulin, as this not only facilitates the collection of specimens of urine, but also ensures standard conditions while the correct dose is being determined.

The patient should be put on a diet containing about 100 grams of carbohydrate, the greater part of which should be given at breakfast and the evening meal in some arrangement such as the following: breakfast 35, lunch 20, tea 10, and dinner 35 grams. Specimens of urine should be collected every three hours and tested for sugar, the results being charted in the manner illustrated in Fig. 77. As the sugar content of the urine passed during the day is controlled by the morning insulin, and that passed during the night and early morning by the evening

insulin, the dosage can be adjusted so as to render the urine sugar-free throughout the 24 hours.

The initial dose of insulin should be given 20 to 30 minutes before breakfast, and should not exceed 10 units. The action of insulin reaches its maximum in most cases during the period 3 to 6 hours after it is injected; the presence of sugar, therefore, in the specimen 0 to 3 hours after the injection does not necessarily mean that insufficient insulin has been given. If, however, after 2 days on a morning dose of 10 units the 3 to 6-hour specimen still contains sugar, an evening dose of 5 units must be given. The insulin should then be increased by 2 units every other day until the urine is sugar-free. In severe cases, especially if ketone bodies are present in the urine, the increase can be made more rapidly. It is advisable to keep the morning and evening doses approximately equal, the morning being, if anything, the larger of the two; some diabetics, however, always require more insulin in the evening. In mild and moderately severe cases this method of adjusting the dosage of insulin usually does not present much difficulty; but, in the more severe cases in which large doses are required, there is the danger that the blood-sugar may fall too low during the 3 to 6-hour period after the injection, with the result that the patient experiences the symptoms of hypoglycaemia. If the dose of insulin is lowered in order to avoid this, sugar often returns in the specimen passed immediately before the next injection, and a better method is to introduce what are known as 'buffer' meals at 11 a.m. and 10 p.m. respectively; these buffers consist of 10 or 15 grams of carbohydrate in any convenient form, and serve to prevent wide fluctuations in the blood-sugar. When the insulin has been adjusted so that the urine is sugar-free on a diet containing about 100 grams of carbohydrate the next step is to increase the diet.

It is now generally agreed that the amount of carbohydrate should be considerably higher than was formerly thought to be desirable, and the fat correspondingly lower, but opinion is divided on the optimum figures for, and the ideal relationship between, these substances. The carbohydrate in uncomplicated cases should be fixed somewhere between 130 and 200 grams according to the age, occupation, and appetite of the patient. Young patients, especially those engaged in manual labour, will require relatively large amounts of carbohydrate, if hunger, fatigue, and loss of weight are to be prevented. In such patients the protein may well be increased by 10 or 20 grams. The fat should not exceed 100 grams and, if the carbohydrate is as high as 200 grams, can with advantage be reduced to 75 grams without unduly lowering the calorie value of the diet. This type of diet has several advantages of which the most remarkable is that patients usually require no more, and often less, insulin than under the old-fashioned low carbohydrate and high fat diet. The reason for this is not known, but it has been shown that insulin acts better in the presence of excess of carbohydrate. Other advantages are that the diet is less restricted, ordinary bread can be used in the place of expensive and unappetizing diabetic foods, and the urine is kept free from ketone bodies.

*Proportions
of fat and
carbohydrate
in diet*

*High
carbohydrate
diet*

It has been found that diabetics do better if their weight is rather less than normal; if, therefore, the patient is overweight the fat should be further reduced to 50 grams. It may also be necessary to reduce the protein, but the carbohydrate should be kept relatively high—not less than 100 grams.

There are some who advocate giving as much as 250 to 300 grams of carbohydrate but, in order to do this without greatly increasing the insulin requirement, the fat must be kept as low as 30 to 50 grams. The chief advantage of this type of diet is that it obviates the necessity for weighing any carbohydrate food, but the fat is so low that the diet is as unbalanced in one direction as the low carbohydrate diet was in the other. Most patients prefer the more evenly balanced diet, as it offers greater variation as well as allowing 1 ounce each of bacon and butter in the day.

*Adjustment
of insulin
dosage to
carbohydrate
intake*

While the carbohydrate is being raised the insulin should be increased by 1 unit for every additional 4 grams, although, as explained, it can often later be reduced to, or even below, its original level. As soon as the diet has been fixed, and the dose of insulin determined which will keep the urine sugar-free, it is advisable to determine that the blood-sugar is also within normal limits. This is important because, although the renal threshold usually approximates to 180 mgm. per 100 c.c. (capillary blood), it may be either raised or lowered, the former event being not uncommon in elderly and long-standing diabetics. The best times to estimate the blood-sugar are immediately before each dose of insulin and about 3 to 6 hours after it. In practice, unless the patient is in a hospital or nursing home, it is more convenient to collect the blood immediately before lunch, or before the evening insulin. The blood-sugar immediately before the morning and evening insulin should not exceed 130 mgm. per 100 c.c.; if it is higher than this in the morning, it will probably rise above 180 after breakfast, and the evening insulin should be increased by 2 units. If it exceeds 150 mgm. in the evening, the morning dose should be similarly increased. The blood-sugar three to six hours after breakfast should not be less than 80 to 100 mgm., otherwise hypoglycaemia may result; this may be prevented either by reducing the morning insulin or, if this procedure causes the evening blood-sugar to exceed 150 mgm., by the introduction of a buffer meal at 11 a.m.; if the blood-sugar exceeds 130 mgm. the morning dose is too small, and should be increased by 2 or more units.

*Patients
with raised
renal
threshold
With
lowered renal
threshold*

The possible error of control by urinary examination in cases with a raised renal threshold can thus be eliminated, but the subsequent management is rendered more difficult by the necessity of more frequent blood-sugar estimations. In some diabetics the renal threshold is appreciably lowered, sugar appearing in the urine when the blood-sugar is as low as 140 or even 120 mgm. per 100 c.c. The treatment of these cases is particularly difficult, and any effort to render the urine sugar-free is likely to result in attacks of hypoglycaemia. If the total output of sugar in the urine is estimated on a day when the blood-sugar is known to be

within normal limits, and the result taken as a standard, similar estimations at weekly or monthly intervals may be used as a guide to the diabetic condition, the insulin being increased or decreased accordingly.

Patients should learn to give their own injections, and to vary the site so that the same place is not used more than once a fortnight. The thighs and lower abdominal wall are the most convenient situations, the arms only being suitable when the injections are not given by the patient. A record syringe graduated in units should be used with a No. 20 stainless steel needle; this outfit can be kept in a metal case containing spirit, and carried in the patient's pocket. It is important to teach patients to clean the skin carefully with ether, not to insert the needle as far as the hilt, and to draw back the plunger of the syringe before making the injection. The objects of these precautions are to prevent insulin abscesses, to facilitate the removal of the needle if it breaks, and to make certain that the needle is not in a vein.

*Site and
technique of
insulin
injections*

(4)—Complications of Insulin Injections

The injection of insulin may in rare instances give rise to certain complications at the site of injection of which the following are the most important.

Pain is most often due to a blunt needle, but may also occur with sharp needles especially when large doses of insulin are injected. The use of double or quadruple strength insulin usually obviates this.

Pain

Allergic reactions are manifested by raised red areas which itch intensely, and are not uncommon when insulin treatment is first begun. They usually disappear gradually after a few weeks, and are thought to be due to an impurity in the insulin to which the patient is sensitive. If they persist, it is advisable to change to insulin made from another animal, or it may be sufficient merely to substitute a different brand from the same animal. Very rarely, none of these devices succeed, and an attempt must then be made to desensitize the subcutaneous tissues of the patient's thighs. In order to do this it is necessary first to dilute the brand of insulin chosen so as to obtain a dose sufficiently small not to produce any reaction. The dosage is then gradually increased, injections being given hourly or two-hourly, until the full dose can be taken without reactions. The use of crystalline insulin may avoid this complication, but its price is at present against its continued use.

*Allergic
reactions*

Areas of local fat atrophy are not very uncommon, particularly if insulin is injected frequently into the same place. The cause is unknown and, although recovery in the affected areas usually takes place within about a year if no further injections are made in the vicinity, they occasionally persist much longer. Treatment consists in changing the brand of insulin and the site of injection.

*Insulin
atrophy*

Repeated injections into the same site more often result in the formation of a firm localized subcutaneous swelling, composed of fatty and fibrous tissue, from which further injections of insulin are poorly absorbed.

*Insulin
tumours*

(5)—Overdosage with Insulin

*Insulin
overdosage*

The symptoms of insulin overdose (hypoglycaemia or insulin reactions) are due to a decrease in the blood-sugar, and occur most commonly during the 3 to 6-hour period after an injection. The degree of hypoglycaemia necessary to produce symptoms varies in different patients but, if the blood-sugar is estimated during a reaction, it is usually found to be less than 60 mgm. per cent. The urine, however, may contain sugar on account of its having been secreted during a period when the blood-sugar was much higher, and accumulated in the bladder. The symptoms differ greatly in severity, rapidity and manner of onset, and duration, but certain cardinal manifestations are usually present by which hypoglycaemia can be recognized. In a typical instance the patient experiences a sensation of hunger and weakness, or he may feel faint. Sweating is a constant feature in most cases, and there may also be tremor of the hands and diplopia. Changes in mentality are common, the patient becoming either sullen and aggressive, or emotional and excited. In very severe cases, unless carbohydrate is given, there may be loss of consciousness followed by fits, coma, and very rarely death; a fatal result occurs only when there is a wide error in the dosage. It is extremely important to distinguish between hypoglycaemic and diabetic coma, as the administration of large doses of insulin in the former condition is likely to have fatal consequences. The differential diagnosis is considered below under diabetic coma (see p. 665).

*Hypo-
glycaemic
coma*

Prognosis

Hypoglycaemia is never fatal if recognized early and treated without delay; but, if the patient is allowed to remain unconscious for a long period, death may result in spite of all treatment.

Treatment

The treatment of mild overdoses consists in giving 10 grams of carbohydrate in the form of sugar or glucose. If the symptoms persist, this treatment should be repeated in about 10 minutes, after which they usually disappear. In overdoses, when the patient is unable to take carbohydrate by mouth, glucose can be given by means of a nasal catheter or stomach tube, or per rectum; but it is wise first to inject 1 c.c. of pituitary (posterior lobe) extract. If these measures fail to revive the patient the injection of pituitary extract should be repeated, and a 10 per cent solution of pure glucose given intravenously until consciousness returns.

(6)—Protamine-Insulin and Zinc-Protamine-Insulin

Protamine-Insulin (Retard Insulin)

Attempts have been made in the past to retard the rate of absorption of insulin either by injecting it as a suspension in oil (Leyton) or in combination with vasoconstrictor substances. A new method, introduced by Hagedorn and his colleagues (1936), consists in the injection of an insulin compound of low solubility in tissue fluid. This new compound, called protamine-insulin, is made by combining the usual insulin hydrochloride with a protamine derived from the sperm of a certain species of fish. The substance is absorbed less rapidly than ordinary

insulin, and consequently exerts a slower and more prolonged action than the former, approximately twice as long.

The chief advantage claimed for the new preparation is that it diminishes the wide fluctuations in blood-sugar which occur in some severe diabetics on large doses of insulin, and thereby reduces the glycosuria and risk of hypoglycaemic attacks. Furthermore, ill-effects have not been observed, injections are painless, and both local and general reactions are avoided. Other advantages of protamine-insulin are that by its use it is possible to reduce the number of injections for many children and other diabetics in whom rapid fluctuations in blood-sugar and frequent overdoses would necessitate the injection of ordinary insulin three or more times a day, and the fact that if its administration in large doses is followed by hypoglycaemic attacks these are slower in onset than those which follow overdosage with ordinary insulin. *Advantages*

The disadvantages of this form of insulin are (1) that, owing to its lack of stability, the protamine must be added to the insulin not more than a few weeks before the injection, thus necessitating the use of two sterile solutions instead of one; and (2) that although the use of protamine-insulin before the evening meal results in a low fasting blood-sugar next morning, its relatively slow and less powerful action renders it less efficient than ordinary insulin in controlling the rise in blood-sugar which follows meals containing large amounts of carbohydrate. In attempting to overcome the latter difficulty, Hagedorn and other workers have found that the best results are at present obtained by giving ordinary insulin in the morning and protamine-insulin in the evening, but this method fails to help the diabetic who suffers from severe reactions during the daytime. The dosage of protamine-insulin and best times for giving it in relation to meals are still the subject of experiment, but good results have already been recorded following its use in suitable cases. *Disadvantages*

Zinc-Protamine-Insulin

The most recent advance in the search for the ideal form of insulin is the outcome of Scott's observation that zinc occurs in relatively large quantity in the pancreas, and is present in chemical combination in all preparations of insulin, including crystalline insulin. Scott showed that the addition of zinc to protamine-insulin resulted in a compound which, in animals, has a more prolonged action than either insulin or protamine-insulin. This compound, called zinc-protamine-insulin, has been tested clinically on a series of diabetic patients by Rabinovitch and his co-workers who confirmed Scott's findings, and further showed that the addition of zinc in some way increases the patient's sensitivity to insulin. The results so far obtained indicate that zinc-protamine-insulin may prove more efficient than any other known insulin preparation in keeping the blood-sugar of diabetics within normal limits over long periods of time and in reducing ketosis and hypercholesterolaemia. It appears that, unlike protamine-insulin, the zinc preparation may be successfully used in the treatment of incipient and even established coma. The

discovery of this property of zinc in combination with insulin promises further improvement in the treatment of diabetes.

(7)—Insulin Substitutes

The two great objections to insulin therapy in the past have been its transient effect and the necessity for its injection. The former has to some extent been met by the preparations described above, but the latter remains as formidable as ever, and to overcome it a number of oral substitutes for insulin have been proposed, of which the most important is synthalin (decamethylene diguanidine dihydrochloride). This compound given orally reduces the hyperglycaemia in a certain proportion of cases, but it has now been shown that this reduction is due not to an increased deposition of glycogen in the muscles or liver, but to a diminished formation of dextrose due to the toxic action of the drug on the liver cells. Synthalin should therefore never be used in the treatment of diabetes.

II.—DIABETES IN CHILDREN

Diagnosis The diagnosis of diabetes in childhood may not be easy, and in infancy it is exceedingly difficult. Under one year the disease is rare, and is usually recognized only when coma supervenes; the possibility of diabetes mellitus should, nevertheless, be remembered in any thirsty and marasmic baby. In older children the diagnosis is made on the same lines as in adults.

Treatment Before the introduction of insulin the duration of life in children with diabetes was about two years and, although with the proper use of insulin and diet a healthy life is now possible for every diabetic child, incorrect treatment may result in complications such as infection, coma, cataract, and pseudo-dwarfism. The essentials of correct treatment are insulin, diet, and exercise, the chief difficulty being in the determination of the most suitable type of diet. It is important to remember that, in addition to basal and activity requirements, an allowance must also be made in children for growth.

Basal caloric requirement Fig. 78 shows the basal caloric requirements of children at different ages. To this amount must be added a further 40 per cent of the basal figure for growth, and from 10 to 20 per cent, according to the disposition of the child, for activity. From the age of 12 onwards, if the child plays games or takes any other form of strenuous exercise, the activity allowance must be increased.

AGE IN YEARS	1	2	3	4	5-7	8-10	11-13	14	15	17	17-20
Basal caloric requirements	500	650	700	750	800	900-1000	1100	1300	1400	1500	1550

FIG. 78

To obtain normal growth the diet must contain a sufficient quantity of protein, vitamins, and mineral salts; Fig. 79 gives the protein allowance for children of different ages recommended by the Health Committee of the League of Nations.

AGE IN YEARS				PROTEIN IN GRAMS PER KILOGRAM OF BODY WEIGHT	
1-3	-	-	-	-	3.5
3-5	-	-	-	-	3.0
5-15	-	-	-	-	2.5
15-17	-	-	-	-	2.0
17-21	-	-	-	-	1.5
21 and upwards	-	-	-	-	1.0

(1 kilogram = 2.2 pounds)

FIG. 79

The protein, as in the diet of adult diabetics, is relatively fixed and, although both high and low protein diets have been advocated in the past, they have now been abandoned. The correct relation between the carbohydrate and fat portions of the diet is still open to doubt, but experience has shown that the best physical and most contented states are obtained when a carbohydrate-fat ratio of about 2:1 is employed.

The following diets, which should be given with insulin, are based on *Diets* the above considerations of total calorie value, protein requirements, and carbohydrate-fat ratio, and should contain at least 1 pint of milk.

AGE	TOTAL CALORIES	CARBO- HYDRATE GRAMS	PROTEIN GRAMS	FAT GRAMS
5	1430	140	60	70
10	1650	160	70	80
15	2100	200	90	100

FIG. 80

It is safe to say that all diabetic children should be given insulin as *Insulin* soon as the diagnosis has been made. A convenient method of starting treatment is to put the child on a maintenance diet equivalent to, or not more than 20 per cent above, the basal requirement, together with a small dose of insulin—3 to 5 units—two or three times a day. This process of under-nutrition shortens the period in bed, but should only be maintained until the urine is relatively sugar-free. As soon as this object has been achieved the diet should be raised until the total calorie requirement is being given. Owing to the rapid and wide fluctuations of the blood-sugar in children it is often difficult, or quite impossible, to

adjust the insulin so that all the specimens are sugar-free without causing severe symptoms from overdoses. In order to overcome this difficulty it is sometimes necessary to give insulin three or even four times a day, but it is well to remember that the advantages gained thereby may be more than counterbalanced by the bad moral effect on the child of such frequent injections. The skilful use of buffer meals may be of great assistance in the prevention of overdosage in children, but the use of protamine-insulin seems in many cases to provide the best solution of these difficulties.

Over-nutrition must be avoided in the treatment of diabetic children, but a certain latitude in the choice of food is allowable, and even desirable, in older children, provided that they keep to their diet.

*Complications
of puberty*

With the onset of puberty comes the greatest problem in the control of juvenile diabetes, for the child may begin to resent parental interference, and become uncommunicative about his symptoms, at a time when he is not yet capable of taking over the management of his disease. This is most likely to occur in children who have had diabetes for a relatively short time, patients with long-standing diabetes being less sensitive and, if properly trained, more competent. The best method of dealing with this situation is to make the child entirely responsible for his own treatment, and to be prepared for any complications that may arise. Treated in this way most children soon realize their responsibility and the advantages of keeping themselves fit. In this connexion it is impossible to over-emphasize the importance of teaching children as soon as possible to measure and inject their own insulin; with patience and perseverance on the part of the parent an intelligent child can be taught to do this by the age of six. If children are difficult about their injections a good method of changing their attitude, and so to speak conditioning them in favour of insulin injections, is to keep them in bed whenever they refuse to have them.

Exercise

Lastly, young diabetics should be encouraged to take exercise with the precautions outlined on page 669. All games at school should be allowed, except Rugby football, in which frequent minor injuries are apt greatly to increase the insulin requirement.

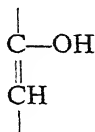
III.—DIABETIC COMA

1.—PATHOLOGY

Normally fatty acids are broken down in the body by a process of β -oxidation, the end-products of metabolism being carbon dioxide and water. In diabetes, owing to failure by the body to oxidize carbohydrate in the normal manner, this process stops short at the stage of butyric acid, from which aceto-acetic acid, β -hydroxybutyric acid and, indirectly,

acetone are formed. These abnormal products of faulty fat metabolism are called ketone or acetone bodies, and may accumulate in the blood and be excreted in the urine, in which aceto-acetic acid and β -hydroxybutyric acid constitute some 30 and 70 per cent respectively of the total, acetone being present only in very small amounts.

In the blood, ketone bodies cause a reduction in the fixed base, and consequent dehydration and decrease in blood-volume as a result of the lowered total salt concentration of the body fluids. At the same time the carbon dioxide content of the alveolar air is reduced from the normal of over 5 per cent to 3 per cent or less in comatose patients, and the alkali reserve falls to 40 or 30 volumes carbon dioxide per 100 c.c. plasma. In addition to these changes ketone bodies exert a toxic action on the body as a whole, especially on the central nervous system, acetoacetic acid being probably the most important in this respect by reason of the presence in it of the enolic group,



2.—DIAGNOSIS FROM HYPOGLYCAEMIC COMA

Diabetic coma must be differentiated from coma due to hypoglycaemia, uraemia, cerebrovascular accidents, cerebral tumour and abscess, the late stages of meningitis, and overdoses of hypnotic drugs (see COMA, p. 345). It is impossible here to discuss the differential diagnosis of any but the first of these conditions, but it should be remembered that glycosuria is not uncommon in diseases of the brain and meninges, and that ketosis should be considered in any case of prolonged coma, especially if it is preceded by vomiting. In all cases of coma every effort should be made to obtain a history and, when this is unobtainable, the patient's clothing should be searched for circumstantial evidence in the form of lumps of sugar, and the thighs for marks of recent injections.

In the diagnosis between hypoglycaemia and diabetic coma neither the history nor these simple investigations may be of any assistance, and it is therefore essential to bear in mind the characteristic features of both conditions. The onset of hypoglycaemic coma is typically sudden, and most likely to occur three to six hours after an injection of insulin, the patient having previously been in good health or having had milder symptoms of overdoses. In diabetic coma on the other hand the onset is gradual, and often follows infections, such as a carbuncle, abscess, or acute abdominal condition. *Onset*

Gastro-intestinal disturbances with anorexia and vomiting are a common cause of diabetic coma because the patient, impressed with the importance of taking food after an injection of insulin, is apt to conclude *Gastro-intestinal disturbances*

that, if he is unable to take food, he therefore should not take his insulin; this may result in the production of severe ketosis and coma. Constipation is another contributory factor to the onset of diabetic coma.

Respiration The respiration is shallow and quiet in hypoglycaemic coma, whereas in diabetic coma, deep abdominal breathing—'air hunger'—is a constant and important sign. A smell of acetone in the breath of a comatose patient is very suggestive of diabetic coma, and may occasionally be present when sugar and ketone bodies are absent from the urine; in such cases large numbers of casts are always present.

Dehydration Dehydration is absent in hypoglycaemic coma. In severe and long-standing cases of uncontrolled diabetes leading to diabetic coma, dehydration can often be easily recognized in the sunken appearance, low eye-ball tension, rapid feeble pulse, and dry skin of the patient. By contrast, the skin in hypoglycaemic coma is usually moist with sweat.

The tongue Less constant points in the differential diagnosis are sometimes to be found in the tongue, which is generally dry and furred in diabetic and natural in hypoglycaemic coma; and in the temperature, which tends at first to be subnormal in the former and normal in the latter condition.

Reflexes The signs in the nervous system are not diagnostic of either state, but the reflexes may be absent in diabetic coma, whereas in hypoglycaemic they tend to be brisk, and there may be signs of hemiplegia such as an extensor plantar response.

Urine In diabetic coma the urine contains large quantities of sugar and ketone bodies; in hypoglycaemic coma, although for reasons given above sugar may be present in the urine, ketone bodies are absent.

Blood-sugar estimation The most conclusive evidence is provided by the blood-sugar; in diabetic coma this always exceeds 200 mgm. per 100 c.c. and is usually much higher, i.e. 400 to 800 mgm.; in hypoglycaemic coma it is always less than 100 mgm. and usually about half this figure.

3.—TREATMENT

Incipient coma

It is usually possible to prevent diabetic coma if efficient treatment is instituted as soon as the first symptoms of onset occur. In all cases of acute infection the urine should be tested twice a day for sugar and once for ketone bodies. If the latter are absent it is sufficient to increase the insulin daily by 2 to 5 units, according to the severity of the infection, until the urine is sugar-free, but if there is marked ketosis, the patient must be put to bed and given the carbohydrate portion of his diet only, in some such form as glucose in lemon, toast, and skimmed milk. Large quantities of fluid should be given, and the patient's bowels well opened with castor oil or calomel and an enema. Specimens of urine should be tested every three hours, and insulin given at six-hour intervals instead of twice a day, until ketone bodies are absent. Careful examination

must also be made for local collections of pus which should be drained under a local anaesthetic or under gas and oxygen anaesthesia. In cases of acute gastro-intestinal disturbance coma may often be prevented by instructing diabetics always, if possible, to take the carbohydrate portions of the diet and their usual insulin. If vomiting makes this impossible half the amount of insulin should be taken without food.

With established coma the details of treatment permit of considerable variation, but the general principles remain the same in all cases. These consist in treating shock, removing sources of acute sepsis whenever possible, and giving sufficient carbohydrate and insulin to free the blood of ketone bodies. *Established coma*

Shock is often a prominent feature in severe diabetic coma, and is recognized by the cold, collapsed, and dehydrated state of the patient. Treatment consists in the application of heat, and the administration of fluids and stimulants, and must not be delayed. Heat is best applied by means of an electric blanket but, if this is not available, a hot-air bath can be improvised with the aid of cradles, blankets, and a small electric radiator. Hot-water bottles are inefficient and dangerous on account of the severe burns which may follow their use. Fluids, in the form of glucose-saline, are best given either by a stomach tube or intravenously, the latter being the better route when a rapid pulse and falling blood-pressure indicate the presence of peripheral circulatory failure. The amount of fluid and the strength of the glucose-saline solution depend upon the condition of the patient but, in all except desperate cases, it is safe to start with a pint of 10 per cent glucose in physiological saline, and to repeat this in three hours if necessary. To prevent death from circulatory failure in desperate cases it is necessary to give intravenously up to 2 pints of 10 per cent glucose in 5 or even 10 per cent saline. In cases with rapid peripheral circulatory failure and a falling blood-pressure, even this treatment may fail to save life; it is possible that in such cases an immediate transfusion, either of blood or better still of plasma, would be more effective. *Treatment of shock*

If the patient is sufficiently conscious to swallow, 10 ounces of water or half-strength physiological saline should be given by the mouth every hour for the first nine or twelve hours. It is probably unnecessary to give sodium bicarbonate unless the patient is deeply comatose, when 3 drachms should be added to the first pint of intravenous glucose-saline. It is doubtful if stimulants do much good but, if a stomach tube is used, caffeine may be given in the form of a pint of hot black coffee together with glucose and 2 ounces of castor oil. Superficial abscesses should be drained as soon as shock has been treated, but major operations, such as opening the abdomen or amputating a gangrenous leg, should be delayed until the general condition has improved.

The details of treatment by carbohydrate and insulin depend to some extent upon whether it is controlled by blood-sugar or by urine examinations; in the former event there is less danger of converting diabetic into hypoglycaemic coma, and it is therefore safe to proceed *Carbohydrate and insulin*

more quickly. Even if frequent blood-sugar examination cannot be made it is important to discover the initial level as a guide to the early dosage of insulin likely to be required. When control by urinary examination has to be relied upon, specimens must be obtained 3-hourly by catheter, care being taken to avoid infection.

The initial dose of insulin must be given before the result of the blood-sugar examination is known, and will depend upon the depth of the coma and the size of the patient's usual dose of insulin. If the patient is only semi-comatose he should receive an initial injection of 50 units, but, if the coma is deep, this should be increased to 70 or 100 units. Patients who normally take about 100 units or more of insulin daily must have correspondingly larger initial doses of 75, 100, or 150 units. It is important also to give glucose, a safe rule being to give 1 gram per unit of insulin. The dosage of subsequent injections will depend on the blood-sugar figures, if available, or on the amount of sugar in the urine and the clinical condition of the patient.

*Blood-sugar
control*

If the blood-sugar at the end of three hours is about the same as the original level, the initial dose should be repeated, half being given intravenously. If it is higher, the initial dose must be increased by 50 per cent, the glucose being kept the same; if it has fallen appreciably, but still exceeds 300 mgm., half the initial dose should be given with a corresponding amount of glucose. Subsequent dosage of insulin and glucose is determined by the level of the blood-sugar, no injection being made for six hours as soon as 200 mgm. is reached.

*Urine-sugar
control*

When the urine-sugar is used as a control, there is not likely to be any change in the result of Benedict's test at the end of the first three hours and, unless the clinical condition is worse, no insulin should be given for a further three hours. The dose of insulin after six hours depends upon the amount of sugar passed at this time and the condition of the patient. If the urine-sugar has not decreased, and there are no signs of clinical improvement, the initial dose should be increased by 50 per cent; if the coma is less deep, but the urine-sugar the same, the initial dose should be repeated; if the urine-sugar has decreased and the clinical condition is better, half the initial dose should be given. The amount of glucose required is determined as in cases with blood-sugar control. The same method is used at the end of a further six-hour period, by which time, if the patient is going to recover, there are usually signs of improvement. As soon as sugar disappears from the urine insulin must be discontinued until it reappears, and then half the preceding dose given.

When consciousness returns the patient should be given every three hours small fluid feeds containing about 20 grams of carbohydrate, and every six hours an injection of insulin. In this way a gradual return is made to the normal diet and the suitable dose of insulin, the latter remaining temporarily or sometimes permanently greater than it was before coma supervened.

IV.—FACTORS COMPLICATING THE TREATMENT OF DIABETES

These may be physiological, such as exercise and pregnancy, or pathological, such as infection, gangrene, cardiac and renal disease, and operations.

1.—EXERCISE

Diabetics, especially when young, should be encouraged to take exercise, as this not only improves their general health but also tends to lower their insulin requirement. The only dangers associated with exercise are hypoglycaemia and trauma, and games in which the latter is common should be forbidden. The risk of hypoglycaemia is proportional to the severity and duration of the exercise, and can be avoided by decreasing the dose of insulin before exercise, by adding extra carbohydrate, and by arranging that the exercise should not be taken at times when the blood-sugar is likely to be low. For prolonged but mild types of exercise, such as walking or golf, it is advisable to reduce the preceding dose of insulin by about five units, and add 10 grams of carbohydrate to the corresponding meal. In severe forms of exercise, such as running or tennis, the same method should be adopted but, as the activity requirement is much greater, more carbohydrate should be added. In swimming, on account of the danger of hypoglycaemia resulting in drowning, 15 grams of carbohydrate should be taken immediately beforehand, and the bath avoided between 11 a.m. and the midday meal, the best time for bathing being the late afternoon.

2.—PREGNANCY, PARTURITION, AND LACTATION

Successful pregnancies in diabetics have become more frequent since the introduction of insulin. Lactosuria and renal glycosuria are both relatively common in the later months of pregnancy, and must therefore be excluded in the usual way. Diabetes may develop during pregnancy or a diabetic may become pregnant; in either case the treatment is that outlined above, but the calorie value of the diet should be raised by the addition of extra protein and carbohydrate, and the patient should be seen more frequently to prevent the consequences of the rapid loss of carbohydrate tolerance which sometimes occurs. Diabetes which develops during pregnancy is usually mild, and the symptoms may disappear after the puerperium; it is likely, however, to recur in subsequent pregnancies.

During parturition the insulin requirement tends to fall, and the

symptoms of hypoglycaemia must be carefully watched for and promptly treated by giving carbohydrate and adrenaline hydrochloride (10 to 15 minims subcutaneously), but not pituitary (posterior lobe) extract. Diabetics should nurse their babies, provided that their disease is reasonably well controlled and an extra allowance is made in their diet; even on high diets, however, the supply of milk is often scanty.

3.—INFECTIONS

These may be divided into two main groups: (*a*) local conditions, such as septic gums and tonsils, boils, carbuncles, and gangrene; (*b*) generalized diseases, such as colds, influenza, gastro-intestinal disturbances, pneumonia, peritonitis, and tuberculosis.

In all these conditions there is a loss of carbohydrate tolerance, and additional insulin is required. Local infections, if acute, should receive immediate surgical treatment, sufficient carbohydrate and insulin being given before the operation to prevent severe ketosis. If the infection is chronic, the patient's diabetes should first be controlled, the operation then being carried out in the most favourable circumstances.

Gangrene is a serious complication, and requires constant attention. If the disease is not spreading, and the patient's general condition is good, it is best to control the diabetes, and to wait until there is a clear line of separation before amputating; if there are signs of extension of the gangrene, immediate amputation should be combined with the treatment outlined above for incipient coma.

Mild general infections, such as a cold, usually necessitate an addition of two to five units of insulin, but more severe conditions, especially gastro-intestinal disturbances, may necessitate doubling or trebling the dose of insulin. The general principles of treatment in such cases are described under incipient coma (p. 666).

Pulmonary tuberculosis is a not uncommon complication, and should be treated in the usual way. This involves the use of a high calorie diet containing full quantities of protein together with sufficient insulin to keep the blood-sugar within normal limits.

A word of warning is necessary in the treatment of long-standing uncontrolled diabetes in patients with chronic cardiac or renal disease. In these conditions sudden lowering of the blood-sugar is apt to be followed by the rapid onset of cardiac or renal failure. It is wise, therefore, to proceed slowly and, if signs of failure occur, to allow the blood-sugar to rise by reducing or withholding insulin until they disappear.

4.—OPERATIONS

Since the introduction of insulin, operations on diabetics have become very much safer and may be undertaken far more freely than before.

The most important considerations are choice of anaesthetic, and the adjustment of diet and insulin so that the liver contains an adequate store of glycogen and the blood is kept free from ketone bodies. Local, spinal, and gas and oxygen anaesthesia are the most suitable forms; chloroform must never be used, and ether is best avoided or reduced to a minimum.

Operations that are not urgent should be postponed until the patient's diabetes is under control and, if a general anaesthetic is necessary, the following immediate pre-operative treatment should be used. The normal diet and insulin should be continued up to the day of the operation, when the patient receives only the carbohydrate portion of his diet and the usual dose of insulin. One hour before the operation 15 units of insulin should be injected and 30 grams of glucose given by mouth. In emergency operations treatment is similar to that in incipient diabetic coma (p. 666); and it is directed against ketosis, hyperglycaemia being of secondary importance.

In patients with severe and uncontrolled diabetes major operations should be postponed until their general condition has been improved by fluids, insulin, and carbohydrate; for in such patients the dangers of delaying surgical treatment are less than those of immediate operation.

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DIAPHRAGM DISEASES

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Reference may also be made to the following titles:

ABDOMINAL PAIN AND	PERITONITIS, ACUTE
ACUTE ABDOMINAL	PLEURISY
EMERGENCIES	

The diseases of the diaphragm are to a large extent those affecting the serous coverings of its upper and lower surfaces, but include disorders of its muscle and nerve supply.

1.—HICCUP

297.] Hiccup is a sudden spasmodic contraction of the diaphragm unaccompanied by the widening of the larynx which occurs in normal respiration. In most cases hiccup is a temporary condition associated with dyspepsia. Occasionally it forms a manifestation of the same infection as that which occurs in epidemic encephalitis (Gamble, Pepper, and Muller).

Aetiology

Knuthsen, who collected 150 cases of obstinate hiccup, divided the causes into (1) The inflammatory type in which a congested state of the gastric and intestinal mucous membrane is present, as in gastritis, enteritis, hepatitis, and hernia. (2) The irritative type in which the cause may be removed with immediate cessation of the hiccup; this occurs especially in children, and may be caused by swallowing hot or highly-spiced foods, by worms, dentition, pressure upon the vagus nerve, and also by catheterization. (3) The specific type, in which some constitutional element is present including malaria, gout, and rheumatism, and in which hiccup is sometimes brought on by movement of an affected joint. (4) The neurotic type in hysterical subjects following fright, shock, or other sudden emotions. In this last group were also included cases occurring in the course of myelitis, in which hiccup is often exhausting and may even cause death.

Hiccup is due to clonic contraction of the diaphragm; but tonic contraction has been described in emphysema and severe bronchitis, tetanus, strychnine poisoning, and hydrophobia; post-encephalitic tic of the diaphragm with a rate of one a minute has been recorded.

Hiccup complicating acute abdominal disease, such as peritonitis, is usually a bad prognostic sign, but this is said not to hold good in cholera (see p. 179).

Treatment

Removal of the cause of hiccup, if possible, may be followed immediately by cessation. In mild cases the spasm may be abolished by holding the breath as long as possible, or by taking a carminative, such as one fluid ounce of peppermint water or 60 minims of aromatic spirit of ammonia in water, the fluid being sipped by rapidly repeated acts of swallowing. In fevers, antipyretics such as antipyrin, aspirin, and quinine may be effective. In inflammatory conditions, morphine and the use of poultices, cold applications, or lavage of the stomach may be helpful. Vomiting sometimes stops hiccup naturally, or it may be induced, with the same effect, by administration of an emetic. In the irritative type, sedatives such as chloroform, 10 or 20 drops on sugar, or administered by inhalation, has been recommended; nitroglycerin and amyl nitrite have also been used. In the specific cases associated with malaria, gout, or rheumatism, the special treatment for these conditions is necessary, and purgatives and the administration of chloral hydrate and bromide also frequently give relief. In the neurotic type, hysteria, epilepsy, or similar neuroses may require the routine treatment for the condition, and the hiccup may be quieted by chloroform, bromides, chloral hydrate, or tincture of asafetida. Counter-irritation by blistering of the epigastrium or the root of the neck is said to be effectual.

2.—PARALYSIS OF THE DIAPHRAGM

Causes

298.] Paralysis of the diaphragm may be due to various lesions of the central nervous system or of the phrenic nerves. For example, it may

occur in diphtheritic paralysis and acute poliomyelitis. Unilateral paralysis of the diaphragm is frequently produced by phrenicotomy, performed with the object of checking the action of the diaphragm on the side where the lung is the seat of tuberculosis, or of a bronchiectatic or other cavity, in order to produce partial collapse of the lower lobe and so favour closure and healing of the cavity. The result as seen by X-ray examination is that the paralysed half of the diaphragm ascends during inspiration while the unparalysed half descends. The opposite occurs on expiration, but the excursion on the paralysed side is much diminished. In some recorded cases both phrenic nerves have been resected with resulting complete paralysis of the diaphragm, but without serious interference with the respiration (Skillern).

Central lesions, however, are a much more serious cause of diaphragmatic paralysis. The conditions responsible for bilateral paralysis of the phrenic nerves are caries or fracture of the cervical vertebrae, a meningeal tumour in the upper cervical regions, and some progressive nervous diseases, such as acute poliomyelitis, Landry's paralysis, and progressive muscular atrophy. A similar result may be produced when the phrenic nerves are implicated by some cause of peripheral neuritis such as chronic lead or arsenic poisoning. In all such cases other effects as well as paralysis of the diaphragm are liable to be present, and the effect on respiration is likely to be a terminal result. The bases of the lungs become congested and bronchitis or broncho-pneumonia develops.

Central lesions

3.—ACUTE INFLAMMATION OF THE DIAPHRAGM

(1)—Primary and Secondary

Primary

299.] Primary acute inflammation has recently been described as causing sudden severe pain in the upper part of the abdomen, with painful respiration, orthopnoea, and immobility of the diaphragm as shown radiologically (Joannides), breathing being carried on by the thoracic movements. The condition is analogous to lumbago, or fibrositis in other muscles, and acute epidemic myositis (see Vol. II, p. 588); probably some cases attributed to acute pleurisy without physical signs are of this nature. In rare instances it is due to trichinosis and scurvy. The condition is benefited by anti-rheumatic remedies and, unless inflammation of a severe septic nature is present, usually terminates favourably in about a week.

Secondary

Secondary acute inflammation of the diaphragm may be due to acute pneumonia, pleurisy, subphrenic abscess, and probably pericarditis. It causes severe dyspnoea out of proportion to the physical signs.

(2)—Acute Diaphragmatic Pleurisy

Referred pain Acute diaphragmatic pleurisy does not differ pathologically from inflammation in other parts of the pleural membrane, but is specially important because it may suggest an acute abdominal emergency. The costal pleura where it comes into contact with the surface of the diaphragm is supplied by the 10th and 11th thoracic nerves, and the severe pain to which inflammation in this area often gives rise is referred along the terminal parts of these nerves which supply the skin and muscles of the abdomen between the umbilicus and the ilio-inguinal ligament. Costal pain is referred from the peripheral parts of the diaphragm, whereas shoulder-tip pain is due to involvement of the central part of the diaphragm (Capps and Coleman; see also Vol. I, p. 11).

Diagnosis The condition, when it occurs on the right side, is liable to be regarded as appendicitis. Careful examination will often discover friction below the base of the lung, and a few days later the presence of fluid in the pleural cavity may be detected by the discovery of dullness on percussion, and by opacity in the costo-phrenic sinus on X-ray examination.

Acute inflammation of the pleura and of the pleural surface of the diaphragm may leave behind adhesions between the diaphragm, the lung, and the chest wall, and so restrict the movements of the diaphragm. In such cases absence of Litten's sign (see p. 680), diminished movement on the affected side, dullness on percussion, and distant breath sounds are found on clinical examination, and lessened activity of the diaphragm is clearly shown on X-ray examination.

4.—EVENTRATION OF THE DIAPHRAGM

Causes 300.] In eventration of the diaphragm one half, usually the left side, is generally expanded allowing the abdominal viscera to be displaced upwards towards the thoracic cavity (Wood). It may be congenital or the sequel of long-continued increase of abdominal tension or of partial collapse of the lung following, for example, pleuritic effusion which has subsequently been absorbed.

Diagnosis In left-sided cases a large area over the lower part of the thorax giving a tympanitic note is found on percussion, with absence of breath sounds, and frequently gurgling noises in the stomach. On X-ray examination the diaphragm is seen as a sharply defined bow-shaped shadow with the clearer areas of the lung above and of the fundus of the stomach below. This may suggest an erroneous diagnosis of pneumothorax, a large cavity in the lung, or a diaphragmatic hernia, but it gives rise to few, if any, symptoms.

5.-CONGENITAL DIAPHRAGMATIC HERNIA

301.] Diaphragmatic hernia may be either congenital or acquired. In the congenital form some of the abdominal viscera pass upwards covered by a sac of peritoneum, pleura, and thinned diaphragmatic tissue, so as greatly to encroach on the pleural cavity (Morrison and Healy). According to Hume, congenital diaphragmatic hernia undoubtedly occurs through (i) the pleuro-peritoneal hiatus, (ii) the dome, and (iii) through the oesophageal orifice, i.e. the 'thoracic stomach' and para-oesophageal hernia. Jaffe (1894) collected thirteen cases of what he called true congenital diaphragmatic hernia or pouch, two being in foetuses and three in very young children; the majority were on the left side. In eight of these cases death did not take place until adult life. Hedblom (1925) collected 378 cases of diaphragmatic hernia in which operation was performed, but these included the results of both trauma and congenital malformation. The contents of the hernia were most frequently the stomach, intestine, omentum, and colon. The symptoms in these cases had varied in duration from hours to decades of years, and included pain, vomiting, except when lying in certain positions, nausea, symptoms of intestinal obstruction, haemoptysis, and eructations. As regards the thorax, the symptoms included dyspnoea, dysphagia, palpitation, cyanosis, pain referred to the left shoulder, hiccup, and cough. The physical signs most frequently found were hyper-resonance on percussion over the lower part of the chest in one-third of the cases with occasional dullness in the same region, displacement of the heart and asymmetry of the chest; but in a considerable proportion of cases physical examination failed to reveal any abnormality. The differential diagnosis depended chiefly upon X-ray examination which showed some of the abdominal viscera above the diaphragm, and a correct diagnosis was made by this means in about one-third of the cases. In this connexion it may be added that when diaphragmatic hernia is suspected the X-ray examination should be made both with the patient recumbent and erect; oblique views are also valuable (see Fig. 81, A and B). An opaque meal may in some cases give useful information.

*Symptoms
and physical
signs*

A somewhat different type of diaphragmatic hernia, and is limited the oesophagus is congenitally shortened and the sac-like ligament situated in the thorax. Åkerlund collected records of diaphragmatic hernia in connexion with the oesophagus is perforation of

Causes

With regard to treatment, various forms of laparotomy have been performed, and these operations may contain gas ('the subphrenic abscess'). In Hedblom's series death followed operation, ten responsible, and the symptoms of obstruction. As many of the cases, and of other abdominal organs, operation is of subphrenic abscess as Åkerlund and others have advised operation. Subphrenic abscess may be, or pelvic organs, and very



FIG. 81.—A. Lateral view of thorax of man aged 44. Absence of left diaphragm discovered on X-ray examination. The greater part of small intestine is seen lying in left pleural cavity. B. Same case, left oblique view. The stomach is rotated to left and the duodenum runs upwards into the left pleural cavity, proving the condition to have been congenital

Diagnosis

partial which has sub
In left-sided c
giving a tympan
breath sounds, a
X-ray examination
shaped shadow with
fundus of the stomach
of pneumothorax, a lar
but it gives rise to few

or no symptoms in order to avoid the greater risk that is present if strangulation should occur.

6.—ACQUIRED HERNIA

302.] Indirect injury to the diaphragm by a crush, or occasionally direct injury by penetrating wounds, may produce a rupture followed by the passage of some of the abdominal organs into the thorax. In the case of indirect injury, the tear usually takes place at one of the points of embryonic weakness, so that some time after the accident it is difficult to distinguish such a hernia from the congenital cases. The presence of shock accompanied by specially severe dyspnoea, hiccup, and vomiting, after a crush to the body, suggests this diaphragmatic injury; but in the absence of pleurisy and peritonitis the diaphragmatic condition may pass unnoticed, and may be followed by little inconvenience beyond cough, a certain amount of dyspnoea, and digestive disturbances. Severe symptoms may be long delayed, as in a boy who when ten years old fell from a height of forty feet, sustained fractures of his jaw and arm, but had only temporary pain in the abdomen; when sixteen he was attacked acutely with vomiting and epigastric pain and died; at the post-mortem examination the greater part of the stomach and a large part of the left lobe of the liver were found to be in the left pleural cavity; in the interval, the patient had not had any symptoms more significant than slight indigestion and had worked regularly (Ogle). The symptoms and physical signs, however, usually resemble those of true congenital diaphragmatic hernia.

7.—SUBPHRENIC ABSCESS

303.] Subphrenic abscess is the name applied to a collection of pus in contact with the under surface of the diaphragm. Infective material in the upper part of the abdomen is prone to be drawn into this position by the respiratory movements. The resulting abscess may lie either in front of or behind the coronary ligament of the liver, and is limited to the right or left cupola of the diaphragm by the falciform ligament of the liver.

The most frequent of the numerous possible causes is perforation of a peptic ulcer, in which event the abscess may contain gas ('the subphrenic pyo-pneumothorax'); but an appendicular abscess or hepatic suppuration, especially a tropical abscess, is often responsible, and the abscess is then usually on the right side. The prompt surgical treatment of perforation of peptic ulcers, of appendicitis, and of other abdominal emergencies, has diminished the incidence of subphrenic abscess as compared with what it was in the last century. Subphrenic abscess may also originate from the kidney, intestine, or pelvic organs, and very

Causes

*Symptoms
and physical
signs*

rarely spreads downwards from the lung and pleura. Infection is liable to pass through the diaphragm, either by lymphatic spread or by gross rupture, and cause pleural effusion which may go on to empyema. The abscess may occur during the progress of the lesion that causes it, or a considerable interval may elapse between the symptoms of the primary lesion and those due to the abscess. The latter include pain in the hypochondriac region, rise of temperature, vomiting, and general debility. The blood shows a leucocytosis. In a right-sided abscess the percussion dullness of the liver is increased unless the abscess contains gas when there is a hyper-resonant note below the lung resonance and above the dull area. Left-sided abscesses usually contain gas, and the percussion phenomena consist, from above downwards, of the lung resonance, tympanitic resonance from the gas, a narrow dull area from the pus, with the stomach resonance below this. X-ray examination shows the clear area of gas limited above by the shadow of the diaphragmatic arch and presenting quite a different appearance from that of pyo-pneumothorax.

Litten's sign

Litten's sign is a moving horizontal depression on the lower part of the side of the thorax, seen on respiration; it is sometimes diminished when diaphragmatic adhesions are present, it is absent when the diaphragm is paralysed, but persists when a subphrenic abscess is present.

The diagnosis of subphrenic abscess may be confirmed by exploratory puncture with a long needle through one of the lower intercostal spaces.

Treatment

If pus is discovered, the abscess is immediately treated by incision and drainage.

8.—OTHER ABNORMALITIES OF THE DIAPHRAGM

304.] Congenital absence of the left half of the diaphragm has been reported several times, and is compatible with long life. Hypertrophy of the diaphragm is frequent in emphysema. Waxy degeneration of the diaphragm has been recorded by Wells as occurring in pneumonia and other conditions, and may be a cause of death. Tumours of the diaphragm are rare; but fibromyoma, sarcoma, and lipoma have been recorded, and extension of tumours from the chest wall sometimes occurs. The condition of achalasia with dilatation of the oesophagus has been attributed by some authorities to spasm of the diaphragm, but is believed by Chevalier Jackson, Hurst, and others to be due to failure of the muscle fibres at the lower end of the oesophagus to relax normally in the act of swallowing (see article ACHALASIA, Vol. I, p. 118).

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NOTE

An exhaustive analytical index to the *British Encyclopaedia of Medical Practice* will be published on completion of the work. In the meantime, each individual title is separately indexed in the volume to which it belongs, and there are additional references and cross-references to assist the reader in finding whatever information he may require as easily and quickly as possible.

The entries in heavy black type correspond with the individual titles; those in large Roman capitals indicate the additional references and cross-references.

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